PROCEEDINGS

OF THE

LAKE SUPERIOR MINING INSTITUTE

NINETEENTH ANNUAL MEETING

MARQUETTE RANGE

AUG. 31, SEPT. 1, 2, 3, 1914

VOL. XIX

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1914

PRESSES OF IRON ORE
ISHPEMING, MICH.

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MISCELLANEOUS.

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ILLUSTRATIONS AND MAPS.

Monument Erected by the Jackson Iron Co., to Mark the Spot Where the First Forge Was Built by the Jackson Mining Co. in 1847.

OFFICERS.

For the year ending with the close of the annual meeting, September 3rd, 1914.

PRESIDENT.

WM. H. JOHNSTON ....Ishpeming, Mich.
(Term one year).

VICE PRESIDENTS.

FRANCIS J. WEBB......................................Duluth, Minn.
A. D. EDWARDS ....Atlantic Mine, Mich.
(Term expires 1914).

CHARLES T. KRUSE ....Ishpeming, Mich.
CHARLES E. LAWRENCE ....Palatka, Mich.
LUTHER C. BREWER ....Ironwood, Mich.
(Term expires 1915).

MANAGERS.

G. S. BARBER ....Bessemer, Mich.
CHARLES H. BAXTER ....Loretto, Mich.
*STUART R. ELLIOTT ....Negaunee, Mich.
(Term expires 1914).

W. A. SIEBENTHAL ....Republic, Mich.
J. S. LUTES ....Biwabik, Minn.
(Term expires 1915).

TREASURER.

E. W. HOPKINS ....Commonwealth, Wis.
(Term one year).

SECRETARY.

A. J. YUNGBLUTH ....Ishpeming, Mich.
(Term one year).

(The above officers constitute the council).
*To fill vacancy of Wm. H. Johnston, elected to presidency.

OFFICERS.

The following is list of officers elected at the annual meeting, September 1st. 1914, also the officers holding over from the previous year which are indicated by an asterisk.

PRESIDENT.

L. M. HARDENBURG ....Hurley, Wis.

(Term one year).

VICE PRESIDENTS.

*CHARLES T. KRUSE ....Ishpeming, Mich.
*CHARLES E. LAWRENCE ....Palatka, Mich.
*LUTHER C. BREWER ....Ironwood, Mich.

(Term expires 1915).

GEORGE R. JACKSON ....Princeton, Mich.
THOMAS A. FLANNIGAN ....Gilbert, Minn.

(Term expires 1916).

MANAGERS.

*W. A. SIEBENTHAL ....Republic, Mich.
*J. S. LUTES ....Biwabik, Minn.

(Term expires 1915).

HENRY ROWE ....Ironwood, Mich.
M. E. RICHARDS ....Virginia, Minn.
ENOCH HENDERSON ....Houghton, Mich.

(Term expires 1916).

TREASURER.

E. W. HOPKINS ....Commonwealth, Wis.

(Term one year).

SECRETARY.

A. J. YUNGBLUTH ....Ishpeming Mich.

(Term one year).

(The above officers constitute the council).

LIST OF STANDING COMMITTEES FOR YEAR ENDING 1915.

PRACTICE FOR THE PREVENTION OF ACCIDENTS.

C. E. LAWRENCE, Chairman ....Palatka, Mich.
WM. CONIBEAR ....Ishpeming, Mich.
W. H. SCHACHT ....Painesdale, Mich.
M. H. GODFREY ....Virginia, Minn.
P. S. WILLIAMS ....Ramsay, Mich.

CARE AND HANDLING OF HOISTING ROPES.

W. A. COLE. Chairman ....Ironwood, Mich.
O. D. M'CLURE ....Ishpeming, Mich.
J. S. JACKA ....Crystal Falls, Mich.
W. J. RICHARDS ....Painesdale, Mich.
A. TANCIG ....Hibbing, Minn.

PAPERS AND PUBLICATIONS.

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J. H. HEARDING ....Duluth, Minn.
F. W. M'NAIR ....Houghton, Mich.
J. E. JOPLING ....Ishpeming, Mich.
FRANK BLACKWELL ....Ironwood, Mich.

BUREAU OF MINES.

M. M. DUNCAN, Chairman ....Ishpeming, Mich.
F. W. DENTON ....Painesdale, Mich.
A. J. YUNGBLUTH, Secretary ....Ishpeming, Mich.

BIOGRAPHY.

J. H. HEARDING, Chairman ....Duluth, Minn.
R. A. DOUGLAS ....Ironwood, Mich.
M. B. M'GEE ....Crystal Falls, Mich.
W. H. NEWETT ....Ishpeming, Mich.
JAMES FISHER ....Houghton, Mich.

MINING METHODS ON THE GOGEBIC RANGE.

Committee to consist of three members to be appointed later.

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POMPELLY, RAPHAEL ....Dublin, N. H.
VAN HISE, C. R......................................Madison, Wis.
WINCHELL, N. H...........501 East River Road, Minneapolis, Minn.

LIFE MEMBERS.

KELLY, WILLIAM ....Vulcan, Mich.
SILLIMAN, A. P..................................Hibbing, Minn.

ACTIVE MEMBERS.

ABBOTT, C. E..................1405 Minnesota Ave., Bessemer, Ala.
ABEEL, GEORGE H...............................Ironwood, Mich.
ABEEL, GEO. H., JR. ....Ironwood, Mich.
ADAMS, DAVID T...............516 Providence Bldg., Duluth, Minn.
ADGATE, FREDERICK W..........419 Rookery Bldg., Chicago, Ills.
AISHTON, R. H. ....215 W. Jackson Blvd., Chicago, Ills.
ALLEN, R. C...Lansing, Mich.
AMBERG, J. W.......................1400 Fulton St., Chicago, Ills.
AMBERG, WILLIAM A...............1400 Fulton St., Chicago, Ills.
ANDREWS, C. E..................................Escanaba, Mich.
APPLEBY, WILLIAM R........School of Mines, Minneapolis, Minn.
ARMSTRONG, FRANK H............................Vulcan, Mich.
ATKINS, SAMUEL E..............909 Alworth Bldg., Duluth, Minn.

BAER, HENRY L.....................................Hancock, Mich.
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BALL, EDWIN ....Birmingham, Ala.
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BARABE, C. A.....................................Ishpeming, Mich.
BARBER, G. S......................................Bessemer, Mich.
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BENEDICT, C. HARRY .... Lake Linden, Mich.
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BLACKWELL, FRANK .... Ironwood, Mich.
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BOLLES, FRED R................................ Houghton, Mich.
BOND, WILLIAM .... Ironwood, Mich.
BONE, ALFRED .... Princeton, Mich.
BOSS, CLARENCE M...............200 Wolvin Bldg., Duluth, Minn.
BOWDEN, RICHARD .... Trimountain, Mich.
BOWEN, REUBEN .... Pittsburg, Pa.
BOWERS, E. C.................................. Iron River, Mich.
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BREITUNG, EDWARD N............................ Marquette, Mich.
BRETT, HENRY .... Calumet, Mich.
BRETTING, R. C................................ Ashland, Wis.
BREWER, CARL .... Crystal Falls, Mich.
BREWER, LUTHER C.............................. Ironwood, Mich.
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BURDORF, HARRY A......2316 Garfield Ave., S., Minneapolis, Minn.
BURNHAM, R.............936 Metropolitan Bldg., Minneapolis, Minn.
BURR, FLOYD L................................. Vulcan, Mich.
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BUSH, E. G......................909 Alworth Bldg., Duluth, Minn.

CADDY, THOMAS .... Hibbing, Minn.
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CAIRNS, FREDERICK I........................... Houghton, Mich.
CALVERLEY, W. D............................... Houghton, Mich.
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CAMPBELL, D. H................................ Iron River, Mich.
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CARMICHAEL, WILLIAM .... Biwabik, Minn.
CARNAHAN, ARTHUR L...............101 Milk St., Boston, Mass.
CARROL, MICHAEL J............................. Houghton, Mich.
CARROLL, RICHARD .... Houghton, Mich.

CARROLL, JAMES R................................Houghton, Mich.
CARROLL, PHILIP ....Houghton, Mich.
CARSON, JOHN A..................................Appleton, Wis.
CARTER, RAYMOND B...........301 W. Randolph St., Chicago, Ills.
CASH, F. H......................................Kinney, Minn.
CHAMPION, CHARLES ....Beacon, Mich.
CHAMPION, JOHN ....Iron River, Mich.
CHANNING, J. PARKE...............61 Broadway, New York City
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CHARLTON, D. E..................................Virginia, Minn.
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CHINN, WILLIAM P................................Gilbert, Minn.
CHRISTENSEN, GEORGE L..........................Houghton, Mich.
CHRISTIANSEN, PETER....217 Union St., S. E., Minneapolis, Minn.
CHURCH, EDWARD ....Marquette, Mich.
CHYNOWETH, B. F.................................Houghton, Mich.
CLARK, WESLEY ....Copper Falls, Mich.
CLARK, KIMBALL ....Kimball, Wis.
CLIFFORD, J. M..................................Green Bay, Wis.
COKEFAIR FRANK A.............Providence Bldg., Duluth, Minn.
COLE, THOMAS F..................................Duluth, Minn.
COLE, WILLIAM T.................................Ishpeming, Mich.
COLE, CHARLES D.................................Ishpeming, Mich.
COLE, WILLIAM A.................................Ironwood, Mich.
COLE, WILLIAM H.................302 Glencoe Bldg, Duluth, Minn.
COLEMAN, MILTON W...............................Virginia, Minn.
COMSTOCK, HENRY.................................Mineville, New York
COMSTOCK, EHLING H..............................Minneapolis, Minn.
COOK, CHARLES W....Economics Bldg., U of M., Ann Arbor, Mich.
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CONNORS, THOMAS ....Negaunee, Mich.
CONOVER, A. B.........................171 Lake St., Chicago, Ills.
COOPER, CLAUDE H................................Hancock, Mich.
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CORY, EDWIN N...................................Negaunee, Mich.
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CRAM, FRED W....................................Nashwauk, Minn.
CROSBY, GEO. H...................Lonsdale Bldg., Duluth, Minn.
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CUNNINGHAM, MARK H..............................Freda, Mich.

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DAVEY, THOMAS H.................................Eveleth, Minn.

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DAVIDSON, WARD F.............................Iron Mountain, Mich.
DAVIS, W. J...Wakefield, Mich.
DEAN, DUDLEY S.......................87 Milk St., Boston, Mass.
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ELLIOTT MARK ....Virginia, Minn.
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ERICKSON, CARL E.................................Ironwood, Mich.
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FELCH, THEODORE A..............................Ishpeming, Mich.
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FELVER, HOWARD C...............................Houghton, Mich.
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FESING, HERMAN W...............................Houghton, Mich.
FISHER, HENRY ....Lake Linden, Mich.
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HEYN, HOWARD A....................Ishpeming, Mich.
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HINE, S. K....................Girard, Ohio
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HITCHENS, JOHN H....................Iron Mountain, Mich.
HOATSON, THOMAS....................Laurium, Mich.
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HOLMAN, J. WINCHESTER....1420 Monadnock Bldg., Chicago, Ills.
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IMHOFF, WALLACE G..............6805 Penn. Ave., Pittsburg, Pa.
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JACKA, JOSIAH S..............................Crystal Falls, Mich.
JACKSON, C.......................................Madison, Wis.
JACKSON, GEORGE R..............................Princeton, Mich.
JACKSON, FRANK W.......Market and Randolph Sts., Chicago, Ills.
JANSON, F. A.......................................Norway, Mich.
JENKS, C. O..Superior, Wis.
JENKS, FRANK G..................................Marquette, Mich.
JETTNER, AUGUST R. ....171 W. Randolph St., Chicago, Ills.
JEWELL, SAMUEL ....Negaunee, Mich.
JEWETT, FRANK G.....710 Security Bank Bldg., Minneapolis, Minn.
JOBE, WILLIAM H....................................Palatka, Mich.
JOHNSON, R. M....................................Greenland, Mich.
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JOHNSTONE, ORLAND W.............................Duluth, Minn.
JOLLY, JOHN ....Painesdale, Mich.
JONES, B. W...Vulcan, Mich.
JOPLING, ALFRED O..............................Marquette, Mich.
JOPLING, JAMES E...............................Ishpeming, Mich.
JOPLING, M. W....................................Marquette, Mich.
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KARKEET, J. H.............................Iron Mountain, Mich.
KAUFMAN, HARRY L...............................Marquette, Mich.
KEAST, WILLIAM J................................Houghton, Mich.
KEESE, FRANK E..................................Ishpeming, Mich.
KENNEDY, F. A.............University of Wisconsin, Madison, Wis.
KIEREN, JOSEPH ....Gilbert, Minn.
KIRKPATRICK, J. CLARK..........................Escanaba, Mich.
KITTS, THOMAS J.................................Houghton, Mich.
KLEFFMAN, JOHN ....Hibbing, Minn.
KLINGLUND, F. D.....................................Palmer, Mich.
KNAPP, GEO. F..............602 Rockefeller Bldg., Cleveland, Ohio
KNEIP, L. H. P.......................................Palmer, Mich.
KNIGHT, J. B..Norway, Mich.
KNIGHT, R. C..Eveleth, Minn.
KNOX, JOHN JR.....................................Calumet, Mich.
KOEPEL, ED.....................................Beacon Hill, Mich.
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KURTZMAN, P. L.................................McKinley, Minn.

LADD, DAVID H.......................110 Front St., Hancock, Mich.
LAIST, ALEXANDER ....Hancock, Mich.
LAMBRIX, MICHAEL ....Hurley, Wis.
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LANE, ALFRED C..........................Tufts College, Mass.
LANG, S. S.......................................Houghton, Mich.
LA ROCHELLE, LOUIS ....Box 9, Houghton, Mich.
LARSSON, PER ....Striburg, Sweden
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LASIER, F. G...................................Birmingham, Mich.
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LAWTON, CHARLES L............................Hancock, Mich.
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LEOPOLD, N. F....................108 Dearborn St., Chicago, Ills.
LETZ, JOHN F.......................662 12th St., Milwaukee, Wis.
LIBBY, DR. E. M...............................Iron River, Mich.
LINDBERG, JOHN FREDERICK......................Hibbing, Minn.
LINN, A. E.......................................Norway, Mich
LOCHER, W. H......................................Duluth, Minn.
LOHNEIS, HENRY G..............................Virginia, Minn.
LONGYEAR, E. J........710 Security Bank Bldg., Minneapolis, Minn.
LONGYEAR, J. M................................Marquette, Mich.
LONSTORF, GEORGE J...........2301 Grand Ave., Milwaukee, Wis.
LOUDENBACK, CLYDE I..........228 W. Randolph St., Chicago, Ills.
LUKEY, FRANK ....Hurley, Wis.
LUKEY, FRANK G.................................Houghton, Mich.
LUTES, J. S.......................................Biwabik, Minn.
LYNCH, THOMAS F...............................Houghton, Mich

MAAS, ARTHUR E....................352 29th St., Milwaukee, Wis.
MAAS, GEORGE J.................................Negaunee, Mich.
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MACKILLICAN, JAMES A..........................Hibbing, Minn.
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MACOMBER, F. B...............No. 507 S. Clinton St., Chicago, Ills.
MANVILLE, T. F. ....Madison Ave. and 41st Street, New York City
MARS, WILLIAM P...................................Duluth, Minn.
MARSHALL, NEWTON C............................Winona, Mich.
MARTIN, ALFRED ....Crystal Falls, Mich.
MATHER, S. LIVINGSTON...........Rockefeller Bldg., Cleveland, O.
MATHER, WILLIAM G............Rockefeller Bldg., Cleveland, Ohio
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MATTHEWS, ABE, JR.........................Crystal Falls, Mich.
MEADS, ALEXANDER P...........................Marquette, Mich.
MERCER, HARRY T..............................Painesdale, Mich.
MEUCHE, A. H.....................................Houghton, Mich.
MEYERS, WILLIAM R..............................Princeton, Mich

MIDDLEMISS, BRUCE A....Hibbing, Minn.
MILLAR, JOHN M....Escanaba, Mich.
MILLER, L. B....Wade Bldg., Cleveland, Ohio
MILLS, FRANK P....Grand Rapids, Minn.
MITCHELL, PENTECOST ....Duluth, Minn.
MITCHELL, EDWARD ....Marquette, Mich.
MITCHELL, R. J....Eveleth, Minn.
MITCHELL, WILLIAM A....16th and Rockwell Sts., Chicago, Ills.
MITCHELL, SAMUEL J....Marquette, Mich.
MITCHELL, HAROLD E....Eveleth, Minn.
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MONROE, W. G....Iron Mountain, Mich.
MOORE, C. F....920 Newhouse Bldg., Salt Lake City, Utah
MOORE, CLARENCE E....Virginia, Minn.
MORGAN, DAVID T....54 California Ave., Detroit, Mich.
MOWATT, NEVILLE P ....3rd Ave. and Michigan St., Duluth, Minn.
MULLEN, THOMAS M....Houghton, Mich.
MUNGER, CHARLES H....Duluth, Minn.
MUNROE, HENRY S....Columbia University, New York City
MURPHY, C. M....Ishpeming, Mich.
MURRAY, ROBERT ....Hibbing, Minn.
MYERS, ALBERT J....Iron Mountain, Mich.
M'CLURE, O. D....Ishpeming, Mich.
M'CORMICK, EDWARD ....Negaunee, Mich.
M'DONALD, D. B....303 Glencoe Bldg., Duluth, Minn.
M'DOWELL, JOHN ....Hibbing, Minn.
M'GEE, M. B....Crystal Falls, Mich.
M'GONAGLE, WILLIAM A....Wolvin Bldg., Duluth, Minn.
M'GREGOR, SILAS J....Iron Mountain, Mich.
M'INDOE, JAMES A....Norway, Mich.
M'INTYRE, JOHN E....Nogales, Arizona
M'LAUGHLIN, W. J....Loretto, Mich.
M'LEAN, JOHN H....Duluth, Minn.
M'LEAN, RICHARD EARLE....Wells, Delta Co., Mich.
M'NAMARA, THOMAS B....Ironwood, Mich.
M'NAIR, F. W....Houghton, Mich.
M'NEIL, E. D....Virginia, Minn.
M'RANDLE, WILLIAM E. R....Bessemer, Mich.

NELSON, S. T....1170 W. Lake St., Chicago, Ills.
NELSON, JOHN E....Negaunee, Mich.
NEWBY, WILLIAM ....Puritan P. O., N. Ironwood, Mich.
NEWETT, GEORGE A....Ishpeming, Mich.
NEWETT, W. H....Ishpeming, Mich.
NEWTON, L. L....1324 La Salle Ave., Chicago, Ills.
NICHOLAS, THOMAS J....Palmer, Mich.
NICHOLS, F. W....Houghton, Mich.

NICKERSON, H. F....................................Houghton, Mich.
NIXON, JOHN A....................................Ishpeming, Mich.
NOETZEL, BENJAMIN D........................Trimountain, Mich.

OBERG, ANTON C...............503 Manhattan Bldg., Duluth, Minn.
OLCOTT, WILLIAM J.....................................Duluth, Minn.
ORBISON, THOMAS W............................Appleton, Wis.
ORR, FRANK D........................Lyceum, Bldg., Duluth, Minn.
OSBORN, CHASE S...........................Sault Ste. Marie, Mich.
OVERPECK, HOLLIS W...................Box 617, Virginia, Minn.

PAINE, W. A.........................82 Devonshire St., Boston, Mass.
PAINE, FRANCIS W................................Houghton, Mich.
PARKER, RICHARD A............802 Equitable Bldg., Denver, Colo.
PASCOE, PETER W.................................Republic, Mich.
PATRICK, RICHARD S..........314-15 Sellwood Block, Duluth, Minn.
PEARCE, E. L....................................Marquette, Mich.
PELLING, WILLIAM F. JR.......................Carson Lake, Minn.
PENGILLY, EDWARD ....Crystal Falls, Mich.
PENNIMAN, DWIGHT C............Curtis Court, Minneapolis, Minn.
PENTON, JOHN A..............Iron Trade Review, Cleveland, Ohio
PERKINS, SAMUEL J..............................Ironwood, Mich.
PETERSON, A. Y...................................Chisholm, Minn.
PITKIN, S. H......................682 W. Market St., Akron, Ohio
POTTER, OCHA ....Houghton, Mich.
POTTER, W. T....................................Ishpeming, Mich.
POWELL, D. W...................................Marquette, Mich.
POWELL, A. E...................................Marquette, Mich.
PRESCOTT, FRED M...................Oregon St., Milwaukee, Wis.
PRESCOTT, L. L.................................Menominee, Mich.
PRYOR, R. C.....................................Houghton, Mich.
PURSELL, H. E....................................Kewanee, Illinois
QUIGLEY, G. J...Antigo, Wis.
QUINE, JOHN THOMAS.............413 Vine St., Ishpeming, Mich.
QUINN, CLEMENT KRUSE.........................Virginia, Minn.

RAISKY, F. H...Duluth, Minn.
RALEY, ROBERT J..............Ketchi-Gaumi Club, Duluth, Minn.
RANKIN, WILLIAM A............................Painesdale, Mich.
RASHLEIGH, WILLIAM J..............................Aurora, Minn.
RAYMOND, HENRY A.............Rockefeller Bldg., Cleveland, Ohio
REDFERN, JOHN A...................................Hibbing, Minn.
REDNER, A. E..................216 Aurora location, Ironwood, Mich.
REEDER, J. T.......................................Houghton, Mich.
REEDER, EDWIN C.................1917 Fisher Bldg., Chicago, Ills.
REEDER, J. H..Houghton, Mich.
REHFUSS, LOUIS I.................................LaCrosse, Wis.

REIGART, JOHN R....Princeton, Mich.
REIFEL, H. T....Nashwauk, Minn.
REYNOLDS, M. K....Ridge St., Marquette, Mich.
RICE, CLAUDE T. ....1420 Monadnock Bldg., Chicago, Ills.
RICE, JOHN H....Houghton, Mich.
RICE, C. W....Milwaukee, Wis.
RICHARDS, WILLIAM J....Crystal Falls, Mich.
RICHARDS, MORRIS EARL ....Crystal Falls, Mich.
RICHARDS, WILLIAM J....Painesdale, Mich.
RICHARDS, GUY A....Biwabik, Minn.
RICHEY, E. W....211 Railway Exchange Bldg., Chicago, Ills.
RIDLEY, FREDERICK WILLIAM....Calumet, Mich.
ROBERTS, HARRY ....Duluth, Minn.
ROBERTS, ALTON T....Marquette, Mich.
ROBERTSON, HUGH J....Escanaba, Mich.
ROHN, OSCAR ....Butte, Mont.
ROSE, ROBERT S....Marquette, Mich.
ROSKILLY, JOSEPH ....Virginia, Minn.
ROUCHLEAU, LOUIS ....Minneapolis, Minn.
ROUGH, JAMES H....Negaunee, Mich.
ROWE, HENRY ....Ironwood, Mich.
ROWE, WM. C....Bessemer, Mich.
RUMSEY, SPENCER S....610 Wolvin Bldg., Duluth, Minn.
RUNDLE, A. J....Iron Mountain, Mich.
RUSSELL, JAMES ....Marquette, Mich.
RYAN, JOHN A....Iron Mountain, Mich.

SALSICH, L. R....Coleraine, Minn.
SCADDEN, FRANK ....Crystal Falls, Mich.
SCHACHT, WILLIAM H....Painesdale, Mich.
SCHLESINGER H. J....Milwaukee, Wis.
SCHUBERT, GEORGE P....Hancock, Mich.
SEAMAN, A. E....Houghton, Mich.
SEBENIUS, JOHN UNO....Wolvin Bldg., Duluth, Minn.
SEEBER, R. R....Winona, Mich.
SEELYE, R. W....Sault Ste. Marie, Ont.
SELDEN, WILLIAM H., JR....Iron River, Mich.
SELLS, MAX ....Florence, Wis.
SELLWOOD, R. M....Duluth, Minn.
SENTER, A. W....Hubbell, Mich.
SHELDEN, R. SKIFF....Houghton, Mich.
SHELDON, ALBERT F....112 N. Arch St., Marquette, Mich.
SHERLOCK, THOMAS ....Escanaba, Mich.
SHERRERD, JOHN M....340 Spring Garden St., Easton, Pa.
SHERWOOD, M. J....Marquette, Mich.
SHIELDS, IRVIN J....Houghton, Mich.
SHOVE, BRIGHAM W....Ironwood, Mich.

SIEBENTHAL, W. A....................................Vulcan, Mich.
SILL, GEO. A....................507 Germain Bldg., Los Angeles, Cal.
SILLIMAN, THOMAS B............................Coleraine, Minn.
SILVER, C. R........................29 W. Lake St., Chicago, Ills.
SIMMONS, CHARLES ....Beacon, Mich.
SKINNER, MORTIMER B. 558 560 W. Washington Blvd., Chicago, Ills.
SLINEY, DAVID J....................................Ishpeming, Mich.
SMALL, H. H.....................4834 S. Halsted St., Chicago, Ills.
SMITH, FRED ....Kearsarge, Mich.
SMITH, WILLARD J.................................Mohawk, Mich.
SMITH, CARL G....................................Kearsarge, Mich.
SMITH, ALFRED L...................28 Loraine St., Pontiac, Mich.
SMYTH, H. L.......................Rotch Bldg., Cambridge, Mass.
SOADY, HARRY ....Duluth, Minn.
SPARKS, BENJAMIN F..............205 Ruby St., Houghton, Mich.
SPERR, F. W.......................................Houghton. Mich.
STAKEL, CHARLES J...............................Ishpeming, Mich.
STANTON, F. McM...................208 5th Ave., New York City
STANTON, J. R.....................11 William St., New York City
STEPHENS, JAMES ....Ishpeming, Mich.
STRONG, CLARENCE G.........Lunkenheimer Co., Cincinnati, Ohio
SUESS, JOSEPH E...................................Negaunee, Mich.
SULLIVAN, A. J.....................................Chisholm, Minn.
SUTHERLAND, D. E..................................Ironwood, Mich.
SWIFT, GEORGE D....................................Duluth, Minn.
SWIFT, PAUL D......................................Houghton, Mich.

TALBOYS, HENRY H.........717 Providence Bldg., Duluth, Minn.
TAPPAN, WILLIAM M.................................Hibbing, Minn.
TARR, S. W......................610 Wolvin Bldg., Duluth, Minn.
THIEMAN EDWARD ....Florence, Wis.
THOMS, REUBEN KNIGHT..................................Ely, Minn.
THOMPSON, CARMI A.......Room 222, G. N. Bldg., St. Paul, Minn.
THOMPSON, HENRY S...................................Beacon, Mich.
THOMPSON, JAMES R................................Ishpeming, Mich.
TOWNSEND, C. V. R.................................Negaunee, Mich.
TRAVER, WILBER H..................Fisher Bldg., Chicago, Ills.
TREBILCOCK, JOHN ....Ishpeming, Mich.
TREBILCOCK, WILLIAM ....North Freedom, Wis.
TREZONA, CHARLES ....Ely, Minn.
TREVARROW, HENRY ....Negaunee, Mich.
TREVARTHAN, W. J..................................Bessemer, Mich.
TRIPP, CHESTER D........1515 Corn Exchange Bldg., Chicago, Ills.
TRUDGEON, JOHN ....Wakefield, Mich.
TUBBY, CHARLES W.........703 Commerce Bldg., St. Paul, Minn.
TUFTS, JOHN W.................900 Hackett Ave., Milwaukee, Wis.
TURNER, CHAS. N.............Colby-Abbott Bldg., Milwaukee, Wis.

UHLER, FRED WALTER ....Alworth Bldg, Duluth, Minn.
ULRICH, WILLIAM F...........................Chisholm, Minn.
UREN, WILLIAM J..............124 College Ave., Houghton, Mich.

VALLAT, BENJAMIN W..........347 E. Grand Block, Detroit, Mich.
VAN DYKE, W. D..................910 Wells Bldg., Milwaukee, Wis.
VANDEVENTER, VIVIAN H.......................Ishpeming, Mich.
VAN EVERA, JOHN R...........................Marquette, Mich.
VAN EVERA, WILBUR ....Virginia, Minn.
VAN MATER, J. A.......................55 Wall St., New York City
VAN ORDEN, F. L...............................Houghton, Mich.
VIVIAN, JAMES G.................909 Alworth Bldg., Duluth, Minn.
VOGEL, F. A...........................25 Broad St., New York City

WADE, JEPTHA H.....................Wade Bldg., Cleveland, Ohio
WAGNER, JOHN M...............................Houghton, Mich.
WALKER, ROBERT S..................Fidelity Bldg., Duluth, Minn.
WALKER, ELTON WILLARD ....Mass, Mich.
WALL, JAMES S..................................Iron River, Mich.
WALLACE, W. R..................................Houghton, Mich.
WALLACE GEORGE ....Marquette, Mich.
WARE, JOHN FRANKLIN.....Forest and Five Oaks Ave., Dayton, O.
WARE, FRED ....Negaunee, Mich.
WARREN, O. B....................................Hibbing, Minn.
WARRINER, S. D.................437 Chestnut St., Philadelphia, Pa.
WATSON, CHARLES H.........................Crystal Falls, Mich.
WEARNE, WILLIAM ....Hibbing, Minn.
WEBB, FRANCIS J. ....812 Fidelity Bldg., Duluth, Minn.
WEBB, WALTER M...............................Gilbert, Minn.
WELLS, PEARSON ....221 Van Dyke Ave., Detroit, Mich.
WENGLER, MATT P..........1055 Cambridge Ave., Milwaukee, Wis.
WESSINGER, W. E..................610 Wolvin Bldg., Duluth, Minn.
WEST, WILLIAM J.................................Hibbing, Minn.
WHEELWRIGHT, O. W.............................Florence, Wis.
WHITE, WILLIAM ....Virginia, Minn.
WHITE, EDWIN E..............................Ishpeming, Mich.
WHITE, J. W..................1905 E. Superior St., Duluth, Minn.
WHITEHEAD, R. G.................................Alpha, Mich.
WHITESIDE,. JOHN W............................Ironwood, Mich.
WILCOX, LEE L...................................Gilbert, Minn.
WILLARD, PAUL D.................................Hibbing, Minn.
WILLEY, NORMAN W. ....Hibbing, Minn.
WILKINS, WILLIAM ....Ashland, Wis.
WILLIAMS, THOMAS H...............................Ely, Minn.
WILLIAMS, PERCIVAL S...........................Ramsay, Mich.
WILLIAMS, DEAN R..........1213 Majestic Bldg, Milwaukee, Wis.
WILSON, EUGENE B...............................Scranton, Pa.

WILSON, ARTHUR O................................Hibbing, Minn.
WILSON, W. G......................................Palmer, Mich.
WINCHELL, HORACE V........505 Palace Bldg., Minneapolis, Minn.
WINTER, JOSEPH H...............................Negaunee, Mich.
WITHERBEE, F. S............................Port Henry, New York
WOODBRIDGE, DWIGHT E...........Sellwood Bldg., Duluth, Minn.
WOODWORTH, G. L...............................Iron River, Mich.
WOOLF, PERCIVAL J..............Monadnock Bldg., Chicago, Ills.
WORDEN, EUCLID P............571 Summit Ave., Milwaukee, Wis.

YATES, WILLIAM H..............507 Alworth, Bldg., Duluth, Minn.
YOUNG, H. OLIN ....Ishpeming, Mich.
YOUNGS, FRANK W.............................Iron River, Mich.
YOUNGS, G. W...................................Iron River, Mich.
YUNGBLUTH, A. J................................Ishpeming, Mich.

ZAPFFE, CARL ......213 Citizens State Bank Bldg., Brainerd, Minn.
ZIMMERMAN, WALTER G..........................Duluth, Minn.

DECEASED MEMBERS.

ARMSTRONG, J. F........1898
BAWDEN, JOHN T........1899
BENNETT, JAMES H.........
BIRKHEAD, LENNOX 1911
BROOKS, T. B............1902
BULLOCK, M. C..........1899
COWLING, NICHOLAS ...1910
CONRO, ALBERT ....1901.
CLARK, H. S.................
CLEAVES, WILL S.......1910
CHADBOURNE, T. L......1911
CUMMINGS, GEO. P......1911
DANIELS, JOHN 1898
DEACON, JOHN 1913
DICKENSON, W. E.......1899
DOWNING, W. H..........1906
DUNCAN, JOHN 1904
DUNSTON, THOMAS B.......
GARBERSON, W. R.......1908
HALL, CHAS. H...........1910
HARPER, GEORGE V.....1905
HASELTON, H. S.........1911
HAYDEN, GEORGE 1902
HINTON, FRANCIS 1896
HOLLAND, JAMES 1900
HOLLEY, S. H...........1899
HOUGHTON, JACOB 1903
HYDE, WELCOME ....
JEFFREY, WALTER M.. .1906
JOCHIM, JOHN W........1905
KOENIG, GEORGE A......1913
KRUSE, JOHN C..........1907
LUSTFIELD, A............1904
LYON, JOHN B...........1900
MAAS, WM. J.............1911
MARR, GEORGE A........1905
MILLER, A. M............1912
MINER, A. B..............1913
MITCHELL, SAMUEL 1908
M'VICHIE, D..............1906
M'NAMARA, T.. 1912
NINESE, EDMUND 1909
OLIVER, HENRY W......1904
PEARCE, H. A............1905
PERSONS, GEORGE R....1908
POPE, GRAHAM 1912
ROBERTS, E. S..............
ROWE, JAMES 1911
RYAN, EDWARD 1901
SHEPHARD, AMOS 1905
STANLAKE, JAMES 1910
STANTON, JOHN 1906
STEVENS, HORACE J....1912
STURTEVANT, H. B......1910
THOMAS, HENRY 1905
THOMAS, WILLIAM ....
TOBIN, JAMES 1912
TREVARTHEN, G. C.......1898
TRUSCOTT, HENRY 1910
VAN DYKE, JOHN H.....1906
WALLACE, JOHN 1898
WHITE, PETER 1908
WHITNEY, J. D...........1894
WILLIAMS, W. H.........1897

LIST OF DECEASED MEMBERS REPORTED SINCE THE ANNUAL MEETING OF 1913.

DRAKE, J. M....................................November 27, 1913
JEWETT, N. R..1914
LINSLEY, W. B.................................January 10, 1914
COOPER, JAS. B................................February 27, 1914
PHILBIN, D. M.....................................August, 1914

LIST OF PAPERS PUBLISHED IN PRECEDING VOLUMES.

1893—Vol. I.

1894—Vol. II.

1895—Vol. III.

1896—Vol. IV.

1898—Vol. V.

1900—Vol. VI.

1901—Vol. VII.

1902—Vol. VIII.

1903—Vol. IX.

1904—Vol. X.

1905—Vol. XI.

1906—Vol. XII.

1908—Vol. XIII.

1909—XIV.

1910—Vol. XV.

1911—Vol. XVI.

1912—Vol. XVII.

1913—VOL. XVIII.

LIST OF MEETINGS OF THE INSTITUTE AND THEIR LOCALITIES FROM ITS ORGANIZATION TO AUGUST, 1914.

No.	Place.	Date.	Proceedings
1	Iron Mountain, Mich..........	March 22-23, 1893......	Vol. I
2	Houghton, Mich..	March 7-9, 1894	Vol. II
3	Mesabi and Vermilion Ranges.	March 6-8, 1895........	Vol. III
4	Ishpeming, Mich..	August 18-20, 1896.....	Vol. IV
5	Ironwood. Mich........	August 16-18, 1898.....	Vol. V
6	Iron Mountain, Mich..........	February 6-8, 1900.....	Vol. VI
7	Houghton, Mich..	March 5-9, 1901........	Vol. VII
8	Mesabi and Vermilion Ranges	August 19-21, 1902.....	Vol. VIII
9	Ishpeming, Mich....	August 18-20, 1903.....	Vol. IX
10	Ironwood, Mich..	August 16-18, 1904.....	Vol. X
11	Iron Mountain, Mich.........	October 17-19, 1905....	Vol. XI
12	Houghton, Mich..	August 8-10, 1906......	Vol. XII
13	Mesabi and Vermilion Ranges.	June 24-27, 1908	Vol. XIII
14	Ishpeming, Mich..	August 25-27, 1909....	Vol. XIV
15	Ironwood, Mich..	August 24-26, 1910.....	Vol. XV
16	Crystal Falls, Mich...........	August 22-24, 1911.....	Vol. XVI
17	Houghton, Mich........	August 28-30, 1912.....	Vol. XVII
18	Mesabi Range	August 26-30, 1913.....	Vol. XVIII
19	Marquette Range..	Aug. 31 to Sept. 3, 1914	Vol. XIX

Note—No meetings were held in 1897, 1899 and 1907.

RULES OF THE INSTITUTE.

I.

OBJECTS.

The objects of the Lake Superior Mining Institute are to promote the arts and sciences connected with the economical production of the useful minerals and metals in the Lake Superior region, and the welfare of those employed in these industries, by means of meetings of social intercourse, by excursions, and by the reading and discussion of practical and professional papers, and to circulate, by means of publications among its members, the information thus obtained.

II.

MEMBERSHIP.

Any person interested in the objects of the Institute is eligible for membership.

Honorary members not exceeding ten in number, may be admitted to all the privileges of regular members except to vote. They must be persons eminent in mining or sciences relating thereto.

III.

ELECTION OF MEMBERS.

Each person desirous of becoming a member shall be proposed by at least three members approved by the Council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the Council may prescribe), upon receiving three-fourths of the votes cast. Application must be accompanied by fee and dues as provided by Section V.

Each person proposed as an honorary member shall be recommended by at least ten members, approved by the Council, and elected by ballot at a regular meeting, (or by ballot at any time conducted through the mail, as the Council may prescribe), on receiving nine-tenths of the votes cast.

IV.

WITHDRAWAL FROM MEMBERSHIP.

Upon the recommendation of the Council, any member may be stricken from the list and denied the privilege of membership, by the vote of three-fourths of the members present at any regular meeting, due notice having been mailed in writing by the Secretary to him.

V.

DUES.

The membership fee shall be five dollars and the annual dues five dollars, and applications for membership must be accompanied by a remittance of ten dollars; five dollars for such membership fee and five dollars for dues for the first year. Honorary members shall not be liable to dues. Any member not in arrears may become a life member by the payment of fifty dollars at one time, and shall not be liable thereafter to annual dues. Any member in arrears may, at the discretion of the Council, be deprived of the receipt of publications or be stricken from the list of members when in arrears six months; Provided, That he may be restored to membership by the Council on the payment of all arrears, or by re-election after an interval of three years.

VI.

OFFICERS.

There shall be a President, five Vice Presidents, five Managers, a Secretary and a Treasurer, and these Officers shall constitute the Council.

VII.

TERM OF OFFICE.

The President, Secretary and Treasurer shall be elected for one year, and the Vice Presidents and Managers for two years, except that at the first election two Vice Presidents and three Managers shall be elected for only one year. No President, Vice President, or Manager shall be eligible for immediate re-election to the same office at the expiration of the term for which he was elected. The term of office shall continue until the adjournment of the meeting at which their successors are elected.

Vacancies in the Council, whether by death, resignation, or the failure for one year to attend the Council meetings, or to perform the duties of the office, shall be filled by the appointment of the Council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; Provided, That such appointment shall not render him ineligible at the next election.

VIII.

DUTIES OF OFFICERS.

All the affairs of the Institute shall be managed by the Council except the selection of the place of holding regular meetings.

The duties of all Officers shall be such as usually pertain to their offices, or may be delegated to them by the Council.

The Council may, in its discretion, require bonds to be given by the Treasurer, and may allow the Secretary such compensation for his services as they deem proper.

At each annual meeting the Council shall make a report of proceedings to the Institute, together with a financial statement.

Five members of the Council shall constitute a quorum; but the Council may appoint an executive committee, business may be transacted at a regularly called meeting of the Council, at which less than a quorum is present, subject to the approval of a majority of the Council, subsequently given in writing to the Secretary and recorded by him with the minutes.

There shall be a meeting of the Council at every regular meeting of the Institute and at such other times as they determine.

IX.

ELECTION OF OFFICERS.

Any five members not in arrears, may nominate and present to the Secretary over their signatures, at least thirty days before the annual meeting, the names of such candidates as they may select for offices falling under the rules. The Council, or a committee thereof duly authorized for the purpose, may also make similar nominations. The assent of the nominees shall have been secured in all cases.

No less than two weeks prior to the annual meeting, the Secretary shall mail to all members not in arrears a list of all nominations made and the number of officers to be voted for in the form of a letter ballot. Each member may vote either by striking from or adding to the names upon the list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing the ballot with his name, and either mailing it to the Secretary, or presenting it in person at the annual meeting.

In case nominations are not made thirty days prior to the date of the annual meeting for all the offices becoming vacant under the rules, nominations for such offices may be made at the said meeting by five members, not in arrears, and an election held by a written or printed ballot.

The ballots in either case shall be received and examined by three tellers appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected. The ballot shall be destroyed, and a list of the elected officers, certified by the tellers, shall be preserved by the Secretary.

X.

MEETINGS.

The annual meeting of the Institute shall be held at such time as may be designated by the Council. The Institute may at a regular meeting select the place for holding the next regular meeting. If no place is selected by the Institute it shall be done by the Council.

Special meetings may be called whenever the Council may see fit; and the Secretary shall call a special meeting at the written request of twenty or more members. No other business shall be transacted at a special meeting than that for which it was called.

Notices of all meetings shall be mailed to all members at least thirty days in advance, with a statement of the business to be transacted, papers to be read, topics for discussion and excursions proposed.

No vote shall be taken at any meeting on any question not pertaining to the business of conducting the Institute.

Every question that shall properly come before any meeting of the Institute, shall be decided, unless otherwise provided for in these rules, by the votes of a majority of the members then present.

Any member may introduce a stranger to any regular meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

XI.

PAPERS AND PUBLICATIONS.

Any member may read a paper at any regular meeting of the Institute, provided the same shall have been submitted to and approved by the Council, or a committee duly authorized by it for that purpose prior to such meeting. All papers shall become the property of the Institute on their acceptance, and with the discussion thereon, shall subsequently be published for distribution. The number, form and distribution of all publications shall be under the control of the Council.

The Institute is not, as a body, responsible for the statements of facts or opinion advanced in papers or discussion at its meetings, and it is understood, that papers and discussions should not include personalities, or matters relating to politics, or purely to trade.

XII.

SPECIAL COMMITTEES.

The Council is authorized to appoint from time to time special committees to consider and report upon, to the Institute through the Council, such subjects as changes in mining laws, safety devices, the securing and editing of papers on mining methods, definition of mining terms, affiliations with other societies, and such other subjects as the Council shall deem it desirable to inquire into, such reports not to be binding on the Institute except action is taken by the Institute in accordance with the rules, and the Council is authorized to expend not exceeding six hundred dollars in any one year to carry out the purpose of this section.

XIII.

AMENDMENTS.

These rules may be amended by a two-thirds vote taken by letter ballot in the same manner as is provided for the election of officers by letter ballot; Provided, That written notice of the proposed amendment shall have been given at a previous meeting.

PROCEEDINGS OF THE NINETEENTH ANNUAL MEETING, MARQUETTE RANGE.

LOCAL COMMITTEES.

Arrangements.

F. E. Keese, Chairman.

D. J. Sliney		G. R. Jackson
E. N. Cory	R. S. Rose	S. Jewell
C. A. Barabe	O. D. McClure	Austin Farrell
D. W. Powell	Wm. Conibear	H. S. Thompson

Finance.

C. T. Kruse, Chairman.

A. T. Roberts	F. D. Klinglund	H. T. Hulst
Lucien Eaton	H. Huhtala	T. J. Nichols
H. L. Kaufman	J. R. Thompson	H. A. Heyn

Entertainment.

S. R. Elliott, Chairman.

G. F. Ruez		J. H. Rough
W. H. Newett	J. E. Hayden	J. M. Bush
J. R. Van Evera	N. P. Flodin	M. W. Jopling

Transportation.

Geo. A. Newett, Chairman.

H. R. Harris		C. E. Lytle
C. J. Stakel	J. H. Malloy	C. A. Barabe

Reception.

M. M. Duncan, Chairman.

Thos. Walters	S. J. Mitchell	W. W. Graff
G. G. Barnett	Geo. J. Maas	H. L. Smyth
W. P. Belden	J. H. Winter	E. N. Breitung
T. A. Felch	M. J. Sherwood	Jas. Russell
E. E. White	H. O. Young	Jos. Fay
Peter Pascoe	G. S. Hayden	C. V. R. Townsend
J. M. Longyear	J. E. Jopling	W. S. Heggaton

MONDAY, AUGUST 31ST, 1914.

The Nineteenth Annual Meeting of the Lake Superior Mining Institute opened in Ishpeming on Monday, August 31st. Members and guests were met at incoming trains by members of the Local Committees, who escorted them to the Nelson House, where headquarters were established. Here they were supplied with badges, programs, copies of advance papers, and also tickets for local events. Arrangements were also completed for the excursion trip to Detroit, Michigan.

At 9:30 a. m. the party left by special street cars for Union Park, where a First Aid demonstration was held. This feature of the program was under the supervision of the Committee on "PRACTICE FOR THE PREVENTION OF ACCIDENTS," and was the first one held under the auspices of the Institute, and proved very successful. A complete report of the event is published in a special chapter, giving also the list of prize winners.

At 12:30 luncheon was served at the Wawanowin Golf Club by the ladies of Grace Church for 230 guests. Following the luncheon an interesting ball game was witnessed at Union Park between the Ishpeming and Negaunee teams; the Negaunee team being the winner.

At 3:15 the members and guests journeyed by automobiles to the Athens Mine at Negaunee, where a shaft is being sunk, the ultimate depth of which will be over 2,000 feet. The work of concreting is carried down and the steel dividings placed, as sinking progresses. The power plant for hoisting and compressing is operated electrically; current for which is furnished from the hydro-electric plant of the Cleveland-Cliffs Iron Company under whose supervision the development work is being conducted.

The Negaunee Mine, located near the Athens, was next visited. During the past few years a new shaft has been sunk and an entirely new surface plant installed. The new shaft was put in commission in 1913, and is designated as No. 3. The power plant is operated electrically from the hydro-electric plant of the Cleveland-Cliffs Iron Company. The grounds around the property are well kept, shrubbery, vines and flowers adorning the grassy plats, and present a very neat appearance. The steel stocking trestle was a feature of special interest to the visitors, it being the first of its kind erected in the Lake Superior District, and is described in a paper by

S. R. Elliott, Superintendent. The machinery plant is also described in the paper by F. C. Stanford, Chief Electrician. The party then went to Marquette by automobiles over the splendidly macadamized county road which connects the two cities. After inspecting the steel-concrete ore dock of the Lake Superior & Ishpeming Railway at Presque Isle, near Marquette, the party proceeded to the Lake Shore Engine Works, where a demonstration of their underground loading machine was witnessed, attracting much attention. A banquet was tendered the visitors in the pattern shop of the Lake Shore Engine Works, which was artistically decorated for the occasion, and over three hundred guests were served. Lake Superior whitefish was the feature of the menu.

In the evening the citizens of Marquette provided a moving picture entertainment at the opera house which included some special features, among which was an interesting picture of the Kimberly Diamond Mines of South Africa, also a complete set of pictures of the surface and underground equipment of the Witherbee, Sherman Company's mines at Port Henry, New York, the latter set being furnished by Edwin Higgins, Engineer, of The United States Bureau of Mines, and made a specialty of the "SAFETY FIRST" movement as carried on by the Bureau. During the remainder of the evening the Marquette Club and the Elks Club supplied lunches for the visitors. Sleeping cars were provided for those desiring to make the trip to St. Ignace.

TUESDAY, SEPTEMBER 1ST, 1914.

The special train of the Duluth, South Shore & Atlantic Railway left Marquette at six a. m., arriving at St. Ignace at 11 o'clock. Immediately upon the arrival of the train the party boarded the Steamer "CITY OF DETROIT II" of the D. & C. line, for Detroit. A brief stop was made at Mackinac Island. A business session was held on the boat at 2 o'clock, which was called to order by W. H. Johnston, President, of Ishpeming, who delivered the opening address, which was responded to by W. H Emmons, Director, Minnesota Geological Survey, Minneapolis, in behalf of the American Association of State Geologists. F. W. DeWolf, Director, State Geological Survey of Illinois, Urbana, Ills., spoke on the Kern-Foster bill now before Congress; William Kelly, of the Penn Iron Mining Company, Vulcan, Mich., replying to Mr. DeWolf. R. C. Allen, State Geologist of Michigan, spoke in reference to the trip made by the American Association of State Geologists. The addresses are given in full in another chapter.

The following papers were presented in oral abstract:

*Use of Electricity at the Penn and Republic Mines—By Wm. Kelly and F. H. Armstrong, Vulcan, Mich.

*Methods of Stocking Ore on the Marquette Range—By Lucien Eaton, Ishpeming, Mich.

*The Sinking of a Vertical Shaft at the Palms Mine of the Newport Mining Company at Bessemer, Mich.—By Frank Blackwell, Ironwood, Mich.

*Mining Methods on the Marquette Range—Report by Committee.

*Steel Stocking Trestle, at No. 3 Shaft, Negaunee, Mine—By S. R. Elliott, Negaunee, Mich.

*Ventilation in the Iron Mines of the Lake Superior District—By Edwin Higgins, Pittsburg, Pa.

The following papers, in the absence of the authors, were read by title:

*General Outline of Mining Methods Used in the Copper Queen Mine, Bisbee, Arizona—By Joseph Park Hodgson, Bisbee, Arizona.

*Follow-Up System and Method of Recording Injuries in Compliance With the Workmen's Compensation Law—By Herbert J. Fisher, Iron River, Mich.

This concluded the reading of papers for the afternoon session.

On motion by William Kelly, the President appointed the following a Committee on Nominations: William Kelly, Lucien Eaton, William Bond, John A. Redfern and F. W. Sperr.

On motion by F. W. McNair, the President appointed the following a Committee on Resolutions: F. W. McNair, J. S. Lutes, W. H. Newett, Frank Carbis and P. S. Williams.

On motion by D. J. Sliney, the President appointed the following a Committee to audit the books of the Secretary and Treasurer: D. J. Sliney, C. E. Abbott and Thos. A. Flannigan.

Committee to report at the evening session.

*Papers distributed in printed form.

ADDRESS OF WELCOME BY W. H. JOHNSTON, PRESIDENT.

Members and Guests of the Lake Superior Mining Institute: This is the first good opportunity I have had to extend to you in behalf of the members and citizens of the Marquette Range a hearty welcome. After our visit last year to the big steel plant under construction at Duluth and many of the iron mines of Minnesota, we realized how small our mines on the Marquette Range would look in comparison. We, however, prepared a program which we trust will meet your approval. After several conferences with the local members and some correspondence it was decided to spend one day on the Marquette Range and then visit Detroit, the metropolis of our State, and look over some of the large industrial works of which Detroit has many. We were assured of a hearty welcome and that an interesting program would be prepared that would keep us busy during our short stay.

We decided to hold our business meetings on the boat which would give us a good opportunity for the discussion of the excellent papers to be presented, for we would have ample time to do this. At our recent meetings we have had so much work laid out for us of an interesting character that the discussion of papers has been somewhat neglected and I trust that this meeting will be an exception and that we will have a full and general discussion of the papers, for I regard this as one of the important features of our meetings.

I regret that the attendance is not larger and am sure it would have been under normal conditions. Quite a number who expressed their intention of attending the meeting have since notified our Secretary that they would be unable to do so and I have received a telegram since leaving home from one of our ex-Presidents, Mr. W. J. Olcott, expressing his regrets that he could not be with us and wishing us a very successful meeting and delightful trip.

Tomorrow morning a committee from the Detroit Board of Commerce will meet us and I understand have arranged so we will have an opportunity to view the parade of the G. A. R., after which we are to go at once to the Detroit Board of Commerce which is to be headquarters while we are in Detroit.

I desire to take this opportunity to thank the members of our committees who have assisted me in arranging for this meeting.

RESPONSE TO PRESIDENT'S ADDRESS, BY MR. W. H. EMMONS OF MINNESOTA.

Gentlemen of the Lake Superior Mining Institute: On behalf of the American Association of State Geologists, I wish to thank you for your cordial invitation to be with you on this trip. There are, I think, thirty-five state geologists in the United States. Of this number there were twenty on an excursion and meeting which has just terminated, during which we were the guests of Mr. R. C. Allen, Director of the State Geological Survey of Michigan. This morning and last night telegrams began to come from various places for several of these men, and a number who had intended to be present at this meeting found it would be necessary for them to go home, so there are only about ten or a dozen of us left. I wish to express the sincere regrets of those who were not able to attend this meeting.

After spending a number of years in various mining camps in the western part of this country, and then coming to Minnesota a year or two ago, and up here, and visiting the deposits of this region, the most striking thing, it seems to me, about the ore bodies of the Lake Superior country is their great regularity and the great stability of the industries that depend on them. I think that those of us to whose lot it has fallen to be placed in this favored region are to be congratulated particularly at this time when the great mining camps of the West are curtailing production and many of them closing down. We should be particularly grateful that we have these great syngenetic ore deposits of the Lake Superior region which seem to stand the various vicissitudes of finance and politics and weather the storm so well as they are weathering it now. In this connection I would like to say that it seems to me that there is also a very serious responsibility resting on the members of this organization and on all others who are interested in the great deposits of the Lake Superior region. Now at the time when we may say a lower point, or perhaps the lowest point in the trough of the curve of progress is reached, when conditions perhaps are as serious as they have ever been, is the time to think of the great problems in connection with these deposits, in connection with working the lower grade ores and lengthening the life of the deposits, and increasing the stability of the industries depending upon them. In this, of course, we will all have to play a part. I do not wish to anticipate the remarks of my friend, Mr. DeWolf, of Illinois, who will have something to say on that subject. I thank you, Mr. President and gentlemen.

MR. DEWOLF, SECRETARY OF ASSOCIATION OF AMERICA, STATE GEOLOGIST, AND DIRECTOR OF THE ILLINOIS GEOLOGICAL SURVEY.

At a recent meeting of our Association we had up for discussion certain proposed legislation in which we as geologists feel particularly interested. It was suggested that this Institute would very likely be interested in the same matter if, indeed, the subject had not already been brought to your attention. When I spoke to your Secretary and President I was asked to present the subject myself for your consideration and action if desirable.

Congressman Foster from my State introduced a bill at Washington providing for extension of the work of the Bureau of Mines with regard to mine safety and the development of efficient mining, quarrying and metallurgical practices. It is known as the Kern-Foster Bill, (H. R. 15869), and while I might read it to you, it is perhaps enough to say that the gist of this bill is the provision for fifteen additional mine safety stations or crews and for ten mining experiment stations. It may be assumed that these will be distributed throughout the country geographically so as to serve the needs of the industries, and also to meet the constant demand which has been coming for work in various regions.

It is anticipated that each of these safety stations or crews will be manned by a mining engineer. two miners, and a surgeon or physician, besides other routine employes, and if I remember it something like $16,000.00 per year will have to be provided for the support of each of these safety stations or crews. Similarly the mine experiment stations are to be manned by a scientific staff, presumably mining engineers and chemists and will require $25,000.00 a year each. As I understand those who are behind this bill, it is the intention that some of these experiment stations shall be in or near mining camps where mining, milling and metallurgical problems are yet to be solved. Of course this Lake Superior district is important and any scheme would doubtless contemplate the location of an experiment station or a safety station in this district. In general it is planned to associate these experiment stations with existing mining schools, or with State Geological Surveys, or with other State agencies, working along these general lines, and it is probable that co-operative arrangements will be made wherever these stations are placed, so as to result in a combination of resources and activity wisely devoted to local needs.

It is my understanding that this bill is well along but probably will not pass at this session of Congress. The sponsors of the bill hope to pass it early in the next session so that the various State Legislatures which meet during the first part of January may, if they see fit, provide for permanent co-operation with the new federal stations.

The Association of State Geologists has appointed a Committee of five to give this matter special thought and to consult with the Bureau of Mines' authorities, on invitation, in determining the character of work to be done at each of these stations and in bringing about a logical and efficient distribution of the stations. Some of us feel that greater efficiency would perhaps come from strengthening the present main station at Pittsburg, but we know that the logical way to make rapid progress in this line is to bring about a geographical distribution of the work in response to local interest among the mining industries. This course will more quickly induce Congressmen to furnish the necessary funds for this urgent work. Inasmuch as the Government's money is being spent for the purposes which are most strongly supported, and since the needs of the mining industries have been neglected, it seems to our Association that it is desirable to support this bill strongly.

Mr. President, I have presented the matter briefly, but I have the bill here and if any questions are asked I shall be glad to try to answer them. My purpose was to bring this subject to your attention for deliberation.

Question: How much is provided for each station?

Answer: Another bill would provide the appropriations. I believe the estimates provide $25,000.00 annually for each experiment station, and $16,000.00 annually for each safety station or car.

MR. KELLY OF VULCAN, MICHIGAN, RESPONDING.

We on Lake Superior have greatly at heart this proposition of the safety of the men who work in the mines. Perhaps one of the best evidences of the work that is being carried on for this purpose was that shown yesterday by the contests of First Aid Corps from various mines. Most of the mines are adopting measures for First Aid and Rescue work, providing devices to guard the safety of men and coming in closer touch with the men underground to further the safety of life and limb. We have had great aid in this work from the Government car which has been located in our region during the last two or three years and we hope for more of this work. We can, therefore, heartily approve of this proposition to have the work extended broadly throughout the different mining districts of the country. I am sorry to say, however, that a proposition to indorse this measure lies outside of the functions of this Institute. This Institute has a constitution similar to that of the American Institute of Mining Engineers and under it there is no way in which the Institute as a body can be bound by the action of a session of the Institute; nor is there any way provided for taking a consensus of opinion of the body of the Institute outside of its regular routine proceedings. If individual expression can add to this measure and if individual effort with the members of Congress will help, I think we can rest assured that everything possible will be done, and my own opinion is that these individual efforts, if they can be aroused, will be more effective than any expression of opinion passed by a session or convention.

MR. ALLEN OF MICHIGAN.

Gentlemen: It is my impression that some of the members of this organization hear from me too many times during the course of the year. However, I am glad of this opportunity to thank the members of the Lake Superior Mining Institute for the invitation to the Association of American State Geologists to join you on this trip, and particularly to thank those of you who have been so kind and courteous to the visiting geologists. It is one of the traditions of this upper country, both on the iron ranges and in the copper country, that visitors are always well treated and I am sure that you have maintained this tradition in the way you have helped me to show these visiting geologists around the country.

During the last two or three years it has been my good fortune to come into very close contact with many of the mining men of Michigan, more particularly those in the iron mining industry, and I feel that I have been benefitted greatly thereby; that I have been growing; and that I have learned a great deal from you. I derive a great deal of personal satisfaction from my acquaintanceship among you, and I hope that whatever may result from the dealings that we have had, or may have in the future, nothing will intervene to mar our pleasant relations.

We are sorry that all of our members were not able to join us in this trip. It is one of the most desirable features of our Michigan tour and the itinerary was arranged so that all of us would have the opportunity of joining you here. However, we have been moving rapidly since we started about a week ago at Houghton, partly on foot, and by the time we reached St. Ignace some of the older members of our organization were really exhausted and anxious to get home. There are ten of us here and we are all glad that we are here. Speaking for myself, I do not want ever to miss any of these annual excursions of the Mining Institute. Gentlemen, I thank you.

Evening Session.

The evening session was held at 8 o'clock, President W. H. Johnston, presiding. The following papers were presented in oral abstract:

*Mining Methods on the Marquette Range—Report by Committee.

*Hydro-Electric Plant of The Cleveland-Cliffs Iron Company—By F. C. Stanford, Ishpeming, Mich.

In the absence of the authors the following papers were read by title:

*Titaniferous Ores in the Blast Furnace—A Recent Experiment—By D. E. Woodbridge, Duluth, Minn.

*The Caving System of Mining in the Lake Superior Iron Mines—By J. Parke Channing, New York.

After the presentation of papers the Council presented its report as follows:

*Papers distributed in printed form.

REPORT OF THE COUNCIL.

Secretary's report of Receipts and Disbursements from August 18th, 1913 to August 24th, 1914.

RECEIPTS.

Cash on hand August 18th, 1913				$6,496.15
Entrance fees for 1913		$ 320.00		
Dues for 1913		2,280.00		
Back dues, 1910	$ 20.00			
Back dues, 1911	40.00			
Back dues, 1912	115.00	175.00		
Advance dues, 1914	60.00			
Advance dues, 1915	5.00	65.00		
Sale of Proceedings		91.70		
Institute pin		4.00		
Total			$2,935.70	
Interest on deposits			201.29	
Total receipts				3,136.99
Grand total on hand and received				$9,633.14

DISBURSEMENTS.

Stationery and printing	$ 101.00		
Postage	177.20		
Freight and express	33.84		
Exchange	2.45		
Telephone and telegraphing	6.69		
Secretary's salary	750.00		
Stenographic work	60.00		
Editing papers	33.00		
Total		$1,164.18	
Publishing Proceedings	1,028.50		
Advance Papers	211.50		
Photographs, Maps, Cuts, etc	310.33		
Badges for 1913	81.48		
Expenses Duluth meetings, rent and messenger service	3.50		
Committee meetings	10.00		
Total		1,645.31	
Total disbursements			2,809.49
Cash on hand August 24th, 1914			6,823.65
Grand total			$9,633.14

MEMBERSHIP.

	1914	1913	1912
Total	549	518	486
Members in good standing	*524	†483	437
Honorary members	4	4	4
Life members	2	2	2
Members in arrears (2 years)	19	29	43
New members admitted, 1913	71	31	46
New members not qualified	5	4	3
New members added	66	27	43

*Includes 54 in arrears for one year. †Includes 34 in arrears for one year.

TREASURER'S REPORT.

Treasurer's Report from August 18th, 1913, to August 24th, 1914:

Cash on hand, August 18th, 1913	$6,466.15	
Received from Secretary	2,965.70	
Received interest on deposits	201.29	
Paid drafts issued by Secretary		$2,809.49
Cash on hand, August 24th, 1914		6,823.65
Totals	$9,633.14	$9,633.14

The following standing committees were appointed by the Council for the ensuing year:

"PRACTICE FOR THE PREVENTION OF ACCIDENTS."

(Committee to consist of five members).

C. E. Lawrence, Palatka, Mich., Chairman; P. S. Williams, Ramsay, Mich.; Wm. Conibear, Ishpeming Mich.; W. H. Schacht, Painesdale, Mich.; M. H. Godfrey, Virginia, Minn.

"CARE AND HANDLING OF HOISTING ROPES."

(Committee to consist of five members).

W. A. Cole, Ironwood, Mich., Chairman; O. D. McClure, Ishpeming, Mich.; J. S. Jacka, Crystal Falls, Mich.; W. J. Richards, Painesdale, Mich.; A. Tancig, Hibbing, Minn.

"PAPERS AND PUBLICATIONS."

(Committee to consist of five members).

Wm. Kelly, Vulcan, Mich., Chairman; J. H. Hearding, Duluth, Minn.; F. W. McNair, Houghton, Mich.; J. E. Jopling, Ishpeming, Mich.; Frank Blackwell, Ironwood, Mich.

"BUREAU OF MINES."

(Committee to consist of three members).

M. M. Duncan, Ishpeming, Mich., Chairman; F. W. Denton, Painesdale, Mich.; A. J. Yungbluth, Secretary, Ishpeming, Mich.

"BIOGRAPHY."

(Committee to consist of five members).

J. H. Hearding, Duluth, Minn., Chairman: James Fisher, Houghton, Mich.; R. A. Douglas, Ironwood, Mich.; M. B. McGee, Crystal Falls, Mich.; W. H. Newett, Ishpeming, Mich.

"MINING METHODS ON THE GOGEBIC RANGE."

(Committee to consist of three members to be appointed later).

Committees to serve until their successors are appointed; each committee to have power to appoint sub-committees as may be deemed necessary.

The following proposals for membership have been approved by the Council:

Bigelow, Charles A., Manager Pluto Powder Co., Ishpeming, Mich.

Carroll, Philip, Foundryman, Houghton, Mich.

Carroll, Richard Foundryman, Houghton, Mich.

Carroll, James R., Foundryman, Houghton, Mich.

Dibble, Samuel F., Manager General Electric Co., Duluth, Minn.

Doty, Oliver P., Jr., Superintendent Spring Valley Iron Co., Palatka, Mich.

Erdlets, Joseph F. B., Jr., Mining Engineer, 5 London Wall Bldgs., London, E. C.

Eldredge, A. B., Lawyer, Marquette, Michigan.

Green, Arthur C., Sales Engineer, Goodman Manufacturing Co., Chicago, Ills.

Hicok, J. H., Manager Portage Coal & Dock Co., and Jas. Pickands & Co., Hancock, Mich.

Hunner, Hale H., Mining Engineer, Meriden Iron Co., Hibbing, Minn.

Hutchinson, Frank, Chief Engineer, Pittsburg Steel Ore Co., Riverton, Minn.

Kneip, Leo H., Mine Clerk, Cascade Mining Co., Palmer, Mich.

Kreitter, John W., Superintendent Duluth, Missabe & Northern R'y., Proctor, Minn.

Lohneis, Henry G., Assistant Superintendent, Virginia, Minn.

Lukey, Frank G., Representative, A. Milne & Co., Houghton, Mich.

Marshall, N. C., Mining Engineer, Winona, Mich.

Matthews, Charles H., Salesman, General Electric Co., 801 Fidelity Building, Duluth, Minn.

Mathews, Abe, Jr., Mining Engineer, Crystal Falls, Mich.

Mitchell, Edward, General Contractor, Marquette, Mich.

Murphy, C. M., Master Mechanic, Oliver Iron Mining Co., Ishpeming, Mich.

Pearce, Ernest L., Manager Lake Shore Engine Works, Marquette, Mich.

Powell, Arthur E., Civil Engineer, Marquette, Mich.

Rice, Charles W., Pumping Machinery Salesman, Milwaukee, Wis.

Richards, Guy A., Superintendent Williams Mine, Biwabik, Minn.

Russell, James, Publisher, Marquette, Mich.

Selden, William H., Jr., Capitalist, Iron River, Mich.

Sherwood, Myron J., Miner, Marquette, Mich.

Small, Harry H., Sales Manager Goodman Manufacturing Co., Chicago, Ills.

Wilson, Wm. G., Master Mechanic, Cascade Mining Co., Palmer, Mich.

On motion by F. W. McNair, the Secretary was instructed to cast a ballot for the election to membership of the list as approved by the Council.

Report of Committee on Nominations.

Your Committee on Nominations beg leave to submit the following names for officers of the Institute for terms specified:

For President—L. M. Hardenburgh, one year.

For Vice President—G. R. Jackson, T. A. Flannigan, two years.

For Managers—Henry Rowe, M. E. Richards, Enoch Henderson, two years.

For Treasurer—E. W. Hopkins, one year.

William Kelly,
Lucien Eaton,
William Bond,
Jno. A. Redfern,
F. W. Sperr,
Committee.

The Auditing Committee presented the following report:

Your Committee appointed to examine the books of the Secretary and Treasurer, beg leave to report that we have carefully examined same and find the receipts and expenditures shown therein, to be in accordance with the statements of the Secretary and Treasurer for the fiscal year ending August 26th, 1914.

D. J. Sliney,
C. E. Abbott,
Thos. A. Flannigan.

On motion the report of the Committee was adopted.

Report of Committee on the Practice for the Prevention of Accidents.

To The Council and Members of the Lake Superior Mining Institute.

We, the committee on "The Practice for the Prevention of Accidents," submit the following for your consideration and action at the coming meeting, August 31st to September 4th, 1914.

This committee, in session with your president and secretary, held a meeting on Friday, April 10th, 1914, at which was discussed the offer of the American Mine Safety Association, for a joint meeting of the two associations, for the furtherance of a program in "First Aid" and rescue work.

It was decided after due consideration, that owing to only one day of the Institute's time on the Marquette range, that it would be impossible to hold a joint demonstration, but solicited through H. M. Wilson, Engineer in charge, of the Bureau of Mines, a future arrangement of such a demonstration, covering more than one day, to be held in 1915, or at such time as the council may deem wise; also, as the necessity for raising five hundred dollars to defray the expenses that would be entailed at such a meeting, the action of the whole Institute on the proposition, would be needed, to incur this amount, for this worthy project, and that the matter would be placed before the Institute at its coming meeting and try to secure favorable action on this proposition. In lieu thereof, the committee has made arrangements for a "First Aid" demonstration, under the management of the Marquette Range Safety Association.

Due to the vital interest and active work on the various ranges, both from individual companies and through general action of Range Associations and meets, assisted materially by the aid of the Bureau of Mines, all of which has been highly educational, and the results of which are greatly appreciated by mine officials, the committee feels justified in recommending that the expense solicited be allowed, and that the council and members of the Institute, who have encouraged the work thus far, in the last three years, will, by its favorable action, continue the progress along these lines.

Further, the committee would reiterate and call attention to the complete report on recommendations, of the 1913 committee report, for favorable action, and the appointment of a special committee, for the purpose of printing a book on uniform mine rules, working in conjunction with the report published by the American Mining Congress, American Institute of Mining Engineers, the Mining and Metallurgical Society of America, the Colorado Scientific Society, also mine laws of Canada and other countries, which book would help broaden, codify and disseminate general customs covering the whole field of mining operations in the Lake Superior district. This special committee to be composed of five members of the board. theoretical and practical experience; the expense of which is to be borne by the Institute; this to include payment of the committee, for time given to the subject and the employment of a secretary, and other expense of printing and publishing same in book form.

The committee recommends that a vote of sincere thanks and appreciation be given by the Institute, to the officials of the United States government, in charge of the Bureau of Mines car, for the capable demonstration of its work in the Lake Superior district, and the results of education accomplished along these lines.

The committee further recommends, that the present various range associations, composed of superintendents, mining captains and shift bosses, be given further encouragement in the practical work it is showing to the individual miner and employe, by continuing the holding of frequent meetings on the various ranges; in this way disseminating a broad general knowledge of mining operations, particularly that of safety and efficiency in the individual, under extreme and hard conditions met with.

The committee further recommends that every member of the Lake Superior Mining Institute assume an urgent responsibility in furthering this activity of education. Its dissemination along safety and efficiency lines among the thousands of mine employes is important. The newness of the subject, the indifference to overcome, the mixed nationality of the employes all combine to make the work of introduction rather hard of accomplishment. Careful, conscientious work by every member of the Institute is urged.

Respectfully submitted,

CHAS. E. LAWRENCE,
Chairman.

WILLIAM CONIBEAR,
For Committee.

MR. MCNAIR: I question whether the Institute is ready to commit itself to any decision, action or recommendation at the moment. It occurs to me that the proper handling of the report is to receive it; order it printed in the proceedings, and refer questions of action or recommendation involved to the Council.

MR. HIGGINS: I would like to say just one word about the hoisting signals as a matter of information when the subject is discussed. The Gogebic Range Mining Association appointed a committee to investigate the signals on the Gogebic Range and a report was made and submitted. In discussing that subject it may be possible to get a copy of that report. It was found that there were eight to ten different signals for doing the same thing. The consensus of opinion was that the signals should be universalized; that they should be made with respect to three or four of the cardinal signals only. Mr. Jobe of Iron Mountain went into that quite thoroughly so that there would be considerable data to work on when that subject is considered.

The following communication from the Panama-Pacific International Exposition Bureau was read and on motion referred to the Council for consideration:

"Feeling that it will be impossible for me to attend your coming Convention in person, I take this occasion to extend greetings and a cordial invitation in the name of the Panama-Pacific International Exposition, for the Lake Superior Mining Institute to meet in San Francisco in 1915.

"The series of congresses and conventions to be held in that city during the Exposition is becoming a more significant feature every week; as much for the notable character of the associations to meet there and the topics they will discuss, as because of the number that are scheduled. We are now certain that this series of assemblages will attract a larger number of the ablest thinkers and most successful doers from the world at large, than ever were gathered in a single city in one year before. So pronounced has become this feature that those most familiar with the subject have aptly termed it 'ten months' course in world development.'

"Some of the Exhibits will be of special interest to your Institute. Many organizations are planning to have surveys made of the Exposition by committees in advance of their meeting and a syllabus of the exhibits deserving special attention may be printed with reports on the exhibits and comparisons of notes, thus correlating the work of the meeting with the exhibits and obtaining the utmost possible benefit from both.

"I trust this matter will receive the careful investigation of your Institute. With favorable action, a committee should be appointed to make definite arrangements. The Exposition officials and especially the undersigned, will be pleased to assist in every way possible to make your trip to San Francisco a great success.

"We want you and we expect you; and you will never regret your session with us next year. Hoping to hear from you soon and favorably, and expecting to greet you at the Golden Gate in 1915, I remain."

G. F. HATFIELD,
Field Secretary.

Chicago, Ills., August 20th, 1914.

The following communication from the "Manufacturers Record," extending a cordial invitation to hold a meeting in the Birmingham, Alabama, district, was read and on motion referred to the Council for consideration:

"Understanding that the members of your Institute have been considering the possibility of holding an annual meeting in Birmingham in order that they might have the opportunity of seeing for themselves the resources and the development of that section, I wish to take the liberty of urging this very strongly upon your Institute. I trust that at the coming meeting the matter may be brought before the members and careful consideration given to it.

"I need not call your attention to the extent of the resources of ore and coal in the Birmingham district, and in a large part of the area of the mountain region of the South from Virginia to Northern Alabama. In no other way could the members of your Institute have the opportunity of studying these resources and of forming their own conclusions as to their extent and the possibilities of their development, to such advantage as by holding an annual meeting in Birmingham. Such a meeting would be warmly welcomed not only by Birmingham, but by Chattanooga and other leading centers of the iron and steel industry of the South, and I can assure you that every effort would be put forth to make the trip one of interest and of entertainment to all who might attend."

RICHARD H. EDMONDS,
Baltimore, Md., August 10th, 1914. Editor.

MR. ABBOTT OF BESSEMER, ALA.

"I am quite certain that the members of the Institute would be very well pleased with what they would see in the Birmingham District. A great many of the developments there in the last ten years, especially in the iron ores, have been merely the adoption of Lake Superior methods as regards installations of mining equipment and of mining methods.

"We are unusually fortunate in the location of our raw materials. The members of the Institute can see anything and everything from the mining of the ore and coal, to the manufacture of the raw material into a finished product. The steel plant and furnaces are located between the coal deposits and the iron ore deposits, in fact, can be seen from the crest of Red Mountain, which is the main source of the iron ore supply. We have in addition, a by-product plant where coal tar and ammonium sulphate are being recovered from the gas from the coal in the coking process.

"The American Steel & Wire Company has a large plant which will eventually use about six hundred tons of steel per day in the manufacture of wire products. We have many foundries and other industries which would prove interesting. The Birmingham District is the only place in the known world where the raw materials are so well located. The District has its disadvantages also, such as low grade iron and coal which has to be washed.

"I feel that the trip south would be very pleasant for the members of the Institute, and hope you will make it. You can be assured of a very hearty welcome."

The following communication from George H. Crosby, in reference to a meeting on the Cuyuna Range in 1915, was read and on motion referred to the Council for consideration:

"I expected to be present at the Institute meetings to be held at Marquette, August 31st, and September 1st, 2nd and 3rd, 1914, but I find at the last minute that I will not have that opportunity and pleasure, which I regret exceedingly.

"I wish to extend an invitation to the members of the Lake Superior Mining Institute on behalf of the operators of the Cuyuna Range and the citizens of Crosby to hold their next annual meeting on the Cuyuna Range and to make their headquarters at Crosby.

"Crosby has splendid hotel accommodations and is a strictly modern mining town. The Cuyuna iron range is a new country and should be of great interest to all members of the Institute. We have three open-pit mines now in operation and three underground mines, and will have by next year at least three more, which are now approaching the production state.

"Hoping this invitation will be favorably acted upon by members of the Institute."

Duluth, Minn., August 29th, 1914. GEORGE H. CROSBY.

This concluded the business session and reading of papers for the meeting. The papers presented brought out considerable discussion which is printed with the papers. Members are urgently requested to present further discussion of these papers for the next meeting. The subject of "Mining Methods" offers a splendid field for further presentation, and it is to be hoped that this subject will be kept active as long as new conditions develop. The work of shaft sinking and drifting should receive further attention as the constant development in power drills adds greater efficiency in the results obtained.

Excursion to Detroit Under the Auspices of the Detroit Board of Commerce.

DETROIT BOARD OF COMMERCE.
Charles B. Warren—President.
Byres H. Gitchell—Secretary.
A. T. Waterfall—Traffic Commissioner.

Entertainment Committee.

Oliver Phelps, Chairman, M. A. Hanna & Co.

Paul Bagley,
John J. Bagley & Co., Tobacco Manufacturers.

George H. Barbour,
Michigan Stove Co.

Warren S. Blauvelt,
Semet-Solvay Co., Coke Manufacturers.

Frank E. Bogart,
Farrand, Williams & Clark, Wholesale Drugs.

Wayne C. Bogue,
Carnegie Steel Co.

D. C. Delamater,
Delamater Hardware Co., Wholesale Hardware.

L. H. Carlisle,
Cambria Steel Co.

Frank H. Croul,
Detroit Oak Leather Belting Co.

Sherman L. Depew,
F. C. Pingree Sons Shoe Co.

Caleb M. East,
Murphy Iron Works, Automatic Stokers.

William Gerhauser,
Superior Charcoal Iron Co.

Andrew H. Green, Jr.,
Solvay Process Co., Soda Ash Manufacturers.

William G. Henry,
Detroit Stove Works.

Frederick H. Holt,
Jones & Laughlin Steel Co.

J. S. Hageman,
Bethlehem Steel Co.

Henry W. Horton,
Buhl Sons Co., Wholesale Hardware.

F. W. Hutchings,
Lake Superior Iron & Chemical Co.

F. L. Klingensmith,
Ford Motor Co.

Bamlet Kent,
U. S. Engineers.

Abner E. Larned,
Larned, Carter & Co. Overall Manufacturers.

James L. Lee,
Wm. M. Finck & Co., Overall Manufacturers.

Thomas J. Marsden,
Lee & Cady, Wholesale Grocers.

Jay C. McLauchlan,
Pickands, Mather & Co.

P. J. Moran,
Detroit Iron & Steel Co.

William R. Orr,
Detroit Saturday Night.

Percy Owen,
Chalmers Motor Co.

Oliver Phelps, Jr.,
Miller, Selden Electric Co., Construction and Supplies.

Charles M. Roehm,
Roehm & Davison, Wholesale Hardware.

C. W. Russell,
Russell Wheel & Foundry Co., Structural Iron & Mine Cars.

John R. Searles,
Detroit Copper & Brass Rolling Mills.

James Schermerhorn,
The Detroit Times.

W. C. Standish,
U. S. Tire Co.

F. C. Stoepel,
Burnham, Stoepel & Co., Wholesale Dry Goods.

Frederick Stockwell,
Edson, Moore & Co., Wholesale Dry Goods.

Joseph S. Stringham,
Monarch Steel Casting Co.

Robert W. Standart, Jr.,
Standart Brothers, Ltd., Wholesale Hardware.

A. A. Templeton,
Morgan & Wright, Rubber Manufacturers.

James T. Whitehead,
Whitehead & Kales Iron Works, Structural Iron.

Maurice O. Williams,
Michigan Drug Co., Wholesale Drugs.

Frank R. Wylie,
W. H. Edgar & Sons, Wholesale Sugar.

PROGRAM.

Wednesday, September 2nd.

8:30 a. m.—The City of Detroit II will dock at the foot of Third Street.

9.00 a. m.—Visitors will be escorted to seats tc review G. A. R. parade,

1:00 p. m.—Luncheon in Board of Commerce dining room.

2:30 p. m.—Leave Detroit Board of Commerce building for boat at foot of Third Street, going to the Detroit Copper & Brass Rolling Mills, the Detroit Iron & Steel Company's furnaces, and the Semet-Solvay Company's coke ovens,

5:30 p. m.—Boat returns to foot of Third Street.
Free time until:
8:15 p. m.—Temple Theater.

Thursday, September 3rd.

9:00 a. m.—Assemble at Detroit Board of Commerce building.
9:30 a. m.—Leave by Woodward Avenue street cars marked "Log Cabin" for Ford Motor Company. After inspection of plant, return to Ferry dock at right-hand side of street, foot of Woodward Avenue, taking ferry boat to Belle Isle.
1:30 p. m.—Luncheon at the Detroit Boat Club.
2:30 p. m.—Ride around Belle Isle in automobiles then to the Chalmers Motor Company. After inspection of plant, guests will return at their convenience by street car for down town.

WEDNESDAY, SEPTEMBER 2ND.

Members of the reception committee with Oliver Phelps, Chairman, boarded the steamer from a tug at six o'clock in the morning to receive the party and complete the plans for the visit at Detroit, such was the interest manifested for the visitors from the North. The steamer docked at eight o'clock, and the party was escorted to the new Chamber of Commerce building where a luncheon was prepared. During the forenoon the visitors were afforded an opportunity to view the G. A. R. parade. After the luncheon, Chas. B. Warren, President of the Chamber of Commerce, in a brief address extended to the Institute a cordial welcome to which W. H. Johnston, President, William Kelly and James Russell responded in behalf of the visitors. The party then boarded a special steamer and was taken for a trip down the river to the plant of the Detroit Copper & Brass Rolling Mills and the Detroit Iron & Steel Company's furnaces and the Semet-Solvay plant. In the evening the members were guests at the Temple Theatre.

THURSDAY, SEPTEMBER 3RD.

The party assembled at the Chamber of Commerce building at nine o'clock and proceeded to the Ford Motor Company's plant where an hour was pleasantly spent in a tour through the works. Automobiles then conveyed the visitors to the Detroit Boat Club on Belle Isle, where a luncheon was served by the club, after which a trip was made around the island. The next stop was at the Chalmers Motor Company's plant where some time was spent in inspecting the various operating departments. The party was then taken to the dock where they boarded the Steamer Detroit II for the return trip to St. Ignace, enroute to their homes in the Iron and Copper Country of Lake Superior.

The members are most enthusiastic over the cordial reception extended to them by the citizens of Detroit, the many interesting places visited, and the entertainment afforded them upon this occasion; their first visit to the metropolis of Michigan.

The following is the report presented by the Committee on Resolutions:

Resolved by the members in attendance at the 1914 meeting of the Lake Superior Mining Institute that we hereby extend our thanks to the Mining Companies of the Marquette Range, the Wawonowin Golf Club, Marquette Club, the Elks Club of Marquette, the Lake Shore Engine Works, the E. J. Longyear Co., and resident citizens for entertainment enjoyed by us while on the Marquette Range, and

Also to those who kindly provided motor cars, the D., S. S. & A. R'y. Co., the D. & C. Navigation Co., and other Railway Companies who have extended courtesies to insure our comfort, and

Also to the Detroit Board of Commerce, the Convention and Tourist Bureau of Detroit, the Detroit Boat Club, the Ford Motor Car Co., and the Chalmers Motor Car Co. for entertaining us and facilitating our visits to points of interest in their City, and

Further, that we particularly appreciate the First Aid Exhibition which we have witnessed at Ishpeming, the spirit and skill shown by the participants, the interest in this work on the part of those who made it possible for the several teams to participate, and the interest of those whose contributions added to the zeal of the contestants.

F. W. McNair,
J. S. Lutes,
W. H. Newett,
Frank Carbis,
P. S. Williams,
Committee.

FOLLOWING IS A PARTIAL LIST OF THOSE IN ATTENDANCE.

Abbott, C. E......Bessemer, Ala.
Allen, R. C........Lansing, Mich.
Archibald, R. S..Negaunee, Mich.
Armstrong, F. H....Vulcan, Mich.
Atkins, S. E.......Duluth, Minn.

Barabe, C. A....Ishpeming, Mich.
Barbour, Edwin H..Lincoln, Neb.
Barnett, G. G...Ishpeming, Mich.
Begole, F. H...Marquette, Mich.
Bengry, W. H.....Palatka, Mich.
Benjamin, F. S....Duluth, Minn.
Berteling, John..Ishpeming, Mich.
Bigelow, C. A..Ishpeming, Mich.
Bittchofsky, A. C.Cleveland, Ohio
Bitters, H......Marquette, Mich.
Blackwell, Frank.Ironwood, Mich.
Bond, Wm.......Ironwood, Mich.
Bowers, E. C..Iron River, Mich.
Bownocker, J. A.Columbus, Ohio
Brown, W. G.......Duluth, Minn.
Brown, P. W..Marquette, Mich.
Buehler, H. A.........Rolla, Mo.

Carbis, F...Iron Mountain, Mich.
Case, P. N....Springfield, Mass.
Champion, Chas....Beacon, Mich.
Charlton, D. E....Virginia, Minn.
Chase, P. P.....Ishpeming, Mich.
Cheyney, H. C.....Chicago, Ills.
Chipman, J. C. W.Ishpeming, Mich
Clancey, James..Ishpeming, Mich.
Clifford, J. M....Green Bay, Wis.
Cole, C. D......Ishpeming, Mich.
Cole, W. T.....Ishpeming, Mich.
Conibear, Wm..Ishpeming, Mich.
Conolly, J. J....Marquette, Mich.
Cory, E. N......Negaunee, Mich.

Davies, W. J....Wakefield, Mich.
Davis, J. M.....Milwaukee, Wis.
DeHaas, N. G...Marquette, Mich.
Derby, E. L.....Ishpeming, Mich.
DeWolf, F. W......Urbana, Ills.
Dickerson, L. R.....Chicago, Ills.
Doty, O. P........Palatka, Mich.
Duncan, M. M..Ishpeming, Mich.
Durham, T. W..Marquette, Mich.

Eaton, Lucien..Ishpeming, Mich.
Edwards, A. D....Atlantic, Mich.
Elliott, S. R.....Negaunee, Mich.
Emmons, W. H.Minneapolis, Minn
Erickson, E. R..Iron River, Mich.

Fay, Joseph....Marquette, Mich.
Felch, T. A.....Ishpeming, Mich.
Fesing, G. F....Houghton, Mich.
Fesing, H. W.....Houghton, Mich.
Flannigan, T. A...Gilbert, Minn.
Flodin, Nels ....Marquette, Mich.
Fogerberg, August.Gwinn, Mich.
Formis, A......Iron River, Mich.
Fink, Fred ....Iron River, Mich.
Fisher, James...Houghton, Mich.

Goodney, S. J..Stambaugh, Mich.
Gow, A. M.........Duluth, Minn.
Graff, W. W....Ishpeming, Mich.
Green, A. C........Chicago, Ills.
Gribble, Thomas.Negaunee, Mich.

Hansen, Chris..Negaunee, Mich.
Hanst, J. F.....Ishpeming, Mich.
Hardgrove, T. H....Gwinn, Mich.
Hart, W. C.....Wakefield, Mich.
Harvey, W. H....Eveleth, Minn.
Harvey, Ed..Iron Mountain, Mich.
Hawes, G. H.......Pittsburg, Pa.
Hayden, J. E...Ishpeming, Mich.
Hearding, J. H.....Duluth, Minn.
Helmer, C. E......Winona, Minn.
Hetzel, H. F.......Pittsburg, Pa.
Heyn, H. A.....Ishpeming, Mich.
Higgins, Edwin....Pittsburg, Pa.
Hise, R. R...........Beaver, Pa.
Hoatson, Chester.Calumet, Mich.
Hoatson, Thomas.Calumet, Mich.
Holman, J. W......Chicago, Ills.
Holmgren, Axle..Ironwood, Mich.
Hopkins, E. W................
.... Commonwealth, Wis.
Hoskins, Samuel....Hurley, Wis.
Hotchkiss, W. O...Madison, Wis.
Howie, T. C........... ....
Huhtala, John.....Palmer, Mich.
Hunt, S. H......Ironwood, Mich.

Ives, L. E.........New York City

Jackson, G. R......Gwinn, Mich.
Jackson, Harry.....Gwinn, Mich.

Jaedecke, Clarence ....
..............Iron River, Mich.
Jenks, F. G.....Marquette, Mich.
Jewell, Samuel..Negaunee, Mich.
Johnson, O. M..Ishpeming, Mich.
Johnson, H. O.....Virginia, Minn.
Johnston, W.H..Ishpeming, Mich.
Jones, Henry.......Gwinn, Mich.
Jopling, J. E....Ishpeming, Mich.
Jory, Wm.......Princeton, Mich.

Kay, G. F.......Iowa City, Iowa.
Keese, F. E.....Ishpeming, Mich.
Kelly, Wm.........Vulcan, Mich.
Kleffman, John...Hibbing, Minn.
Klinglund, F. D....Palmer, Mich.
Knoeffel, A. F..Terra Haute, Ind.
Kohlhaas, F. W..Calumet, Mich.
Kruse, C. T....Ishpeming, Mich.

Lacroix, M. F...Ishpeming, Mich.
Lasier, F. G......Detroit, Mich.
Lawrence, C. E...Palatka, Mich.
Lawton, C. L.....Hancock, Mich.
Lawton, N. O.......Miami, Ariz.
Leonard, C. M......Gwinn, Mich.
Longyear, J. M..Marquette. Mich.
Lukey, Frank ......Hurley, Wis.
Lutes, J. S.......Biwabik, Minn.
Lytle, C. E......Marquette, Mich.

Moss, C. H......Ishpeming, Mich.
Maney, James.....Duluth, Minn.
Mather, S. L.....Cleveland, Ohio
Matthews, A..Crystal Falls, Mich.
Myers, E. R......Cleveland, Ohio
Mildon, H. H...Ishpeming, Mich.
Mildren, John....Ironwood, Mich.
Miller, W. G........Toronto, Ont.
Mitchell, W. A.....Chicago, Ills.
Mitchell, S. J....Marquette, Mich.
Mitchell, Ed.....Marquette, Mich.
Morgan, D. T.....Detroit, Mich.
Moulton, W. H..Ishpeming, Mich.
Moulton, H. O..Ishpeming, Mich.
Murphy, C. M..Ishpeming, Mich.
Myers, Wm......Princeton, Mich.
McDonald, D. B....Duluth, Minn.
McGee, M. B..Crystal Falls, Mich.
McNair, F. W....Houghton, Mich.
McNamara, T. B.Ironwood, Mich.
Nelson, J. E.....Negaunee, Mich.
Nelson, E. R....Ishpeming, Mich.
Newett, Geo. A..Ishpeming, Mich.
Newett, W. H...Ishpeming, Mich.
Newton, L. L....Ironwood, Mich.
Nixon, J. A.....Ishpeming, Mich.
Nolan, Dan .....Ironwood, Mich.

Orr, F. D..........Duluth, Minn.

Pascoe, P. W.....Republic, Mich.
Pellow, Kenneth, C...........
.... Negaunee, Mich.
Pellow, Thomas..Negaunee, Mich.
Perkins, G. H.....Burlington, Vt.
Peterson, Otto...Ironwood, Mich.
Petruscak, Tony.Ironwood, Mich.
Platto, Frank...Ishpeming, Mich.
Powell, D. W....Marquette, Mich.
Pratt, J. H....Chapel Hill, N. C.
Prescott, F. M..Menominee, Mich.

Quigley, G. J........Antigo, Wis.
Quine, J. T.....Ishpeming, Mich.

Raisky, F. H......Duluth, Minn.
Raley, R. J........Duluth, Minn.
Redfern, J. A.....Hibbing, Minn.
Reigart, J. R....Princeton, Mich.
Richards, F. G...Ironwood, Mich.
Richards, M. E..................
...........Crystal Falls, Mich.
Richards, W. J..................
...........Crystal Falls, Mich.
Richards, W. A................
............Crystal Falls, Mich.
Richmond, W..Marquette, Mich.
Roberts, A. T...Marquette, Mich.
Rockwell, F. G..Ishpeming, Mich.
Rough, J. H.....Negaunee, Mich.
Rough, Jas. Jr...Negaunee, Mich.
Ruez, G. F......Ishpeming, Mich.
Russ, Ernest.....Ironwood, Mich.
Russell, Jas....Marquette, Mich.

Salsich, L. R....Coleraine, Minn.
Sampson, John.....Ashland, Wis.
Sawhill, R. V....Cleveland, Ohio
Scadden, Frank ....
...........Crystal Falls, Mich.
Schaus, O. M........Hurley, Wis.
Scheder, M. J......Vulcan, Mich.

Scheiber, H. L..................
Schneider, Theo. Marquette, Mich.
Schubert, Jos. M.. Hancock, Mich.
Schubert, G. P.... Hancock, Mich.
Sedgwick, B. G.. Ishpeming, Mich.
Sellards, E. H... Tallahassee, Fla.
Shannon, C. W.... Norman, Okla.
Sheldon R. F... Marquette, Mich.
Shields, I. J..... Houghton, Mich.
Shields, J. C....... Detroit, Mich.
Shove, B. W..... Ironwood, Mich..
Siebenthal, W. A... Vulcan, Mich.
Sink, Ed....... Marquette, Mich.
Sliney, D J.... Ishpeming, Mich.
Small, H. H........ Chicago, Ills.
Smith, E. A...... University, Ala.
Smith R. T.... Ishpeming, Mich.
Smyth, H. L... Cambridge, Mass.
Soady, Harry ...... Duluth, Minn.
Sperr, F. W..... Houghton, Mich.
Sporley, C. L.... Negaunee, Mich.
Stack G. M...... Escanaba, Mich.
Stafford, E. O.. Marquette, Mich.
Stakel, C. J..... Ishpeming, Mich.
Stanford, F. C.. Ishpeming, Mich.
Stannard, W. L... Calumet, Mich.
Stephens Jas... Ishpeming, Mich.
Stevenson, C. A. Ishpeming, Mich.
Stewart, H. E... Houghton, Mich.
Strong, C. G....... Detroit, Mich.

Talboys, H. H..... Duluth, Minn.
Taylor, J. C..... Houghton, Mich.
Thomas J....... Negaunee, Mich.
Tillson, A. H....... Gwinn, Mich.
Traver, D. R........ Chicago Ills.
Traver, W. H....... Chicago, Ills.
Trebilcock, John. Ishpeming, Mich.
Trebilcock, Wm. N. Freedom Wis.
Trevarrow, Henry ....
.... Negaunee, Mich.
Trumbull, L. W.. Cheyenne, Wyo.

Ulrich, E. O... Washington, D. C.
Uren, W. J..... Houghton, Mich.
Urick, W. H.... Marquette, Mich.

Vailett, B. W...... Detroit, Mich.
Vandeventer, V. H.............
.... Ishpeming, Mich.
VanEvera, W.... Virginia, Minn.

Walker, W. W...... Duluth, Minn.
Waller, F....... Marquette, Mich.
Walters, Thos.. Ishpeming, Mich.
Ware, F........ Negaunee, Mich.
Watson, C. H. Crystal Falls, Mich.
Webb, W. M....... Gilbert Minn.
Webb, F. J......... Duluth, Minn.
Webb, C. E..... Houghton, Mich.
Wells, Pearson.... Detroit, Mich.
Westergren, Arthur ....
.... Ironwood, Mich.
White, Wm....... Virginia, Minn.
White, E. E.... Ishpeming, Mich.
White, L. C.. Morgantown, W. Va.
Whitney, Lowe.. Iron River, Mich.
Wieland H. J. E..............
.... Crystal Falls, Mich.
Williams, R. Y...... Urbana, Ills.
Williams, P. S..... Ramsay, Mich.
Wills, G. M..... Marquette, Mich.
Winn, Jos.. ....
Wold, A. N....... Hancock, Mich.
Worden, E. P... Milwaukee, Wis.
Wright, C. W...... Eveleth, Minn.

Yates, W. H........ Duluth, Minn.
Yungbluth A. J. Ishpeming, Mich.
Yungbluth, R. O. Ishpeming, Mich.

Zimmerman,, W. G. Duluth, Minn.

Mechanical Underground Shovel.

The following description has been furnished of the underground loading machine which was demonstrated on the occasion of our visit at the plant of the Lake Shore Engine Works, on Monday, August 31st.

The loader is designed for use in iron, copper and coal mines, in drifts 8x8 ft. and possibly smaller. The machine has an extreme height of 5 ft. from the top of the rail, width of 3 ft. 9 in. and an extreme length of 14 ft., including the shovel, or 11 ft. without the shovel. It can be arranged for operation on any gauge track, is self-propelled, compact and weighs 6500 lbs. The rubber conveyor belt, 22 in. wide, is the only detail in the machine which is not either iron or steel. The capacity is 40 tons of material per hour. The loader may be arranged for operation by air or electricity although it is expected that air operation will be popular because the exhaust from the engine will help to clear the drift of smoke after a blast. It will be possible, however, to change the power, on any machine, in an hour's time when the necessary electric equipment is at hand. There are six different motions controlled by one operator. The machine propels itself forward and backward, the conveyor and shovel operate on a vertical arc of 30 degrees and in a radial arc of 60 degrees, respectively; the conveyor belt is driven and there is the driving mechanism of the shovel. With this combination of motions a great deal will probably depend upon the ability of the operator to get the best output from the machine, and this in turn will depend upon his skill and experience in actual service with it.

The loader consists of three distinct parts which may be disconnected with little difficulty when it is required to take the machine from surface to points underground, or from drift to drift. The truck constitutes one portion, the frame with driving mechanism another, and the conveyor belt and shovel the third. All chains for driving are heavy-construction automobile chains. The gear drive from the engine to the main shaft is of the Wuest patented herringbone type. All operating mechanism is completely inclosed, and securely covered so that no dirt can interfere with the operation of the drive.

The digging dipper, which is somewhat cup-shaped, is fitted with teeth on the cutting edge, and hinged at the back. After securing a load, the dipper is revolved through a vertical arc, and its load falls backward upon the rubber conveyor belt. This belt carries the dirt up an incline of about 30 degrees, dumping it at the turn into an iron chute. The latter directs the dirt into the tram car, and both its angle and direction can be changed within certain limits.

It is the intention of the company to manufacture several sizes, adaptable to other mines where conditions are different. The demonstrating machine will go into service soon at the Judson mine, at Alpha, on the Menominee iron range, Michigan.

PAPERS

USE OF ELECTRICITY AT THE PENN AND REPUBLIC IRON MINES, MICHIGAN.*

BY WILLIAM KELLY, AND F. H. ARMSTRONG, VULCAN, MICH.

The object of this paper is to describe the electric equipment at the iron ore mines of Penn Iron Mining Company, Vulcan, Mich., and of Republic Iron Company, Republic, Mich.; to give the results of tests; and to discuss the methods in use from an operating as well as from an efficiency standpoint.

Electricity was introduced at the Penn mines for pumping, hoisting, and compressing air in the spring of 1907, upon the completion of a hydro-electric plant built by that company on the Menominee river about 4 miles from the mines. This plant was described in a paper[1] presented before the Lake Superior Mining Institute. A paper[2] presented at a meeting of the same Institute describes some of the operating features, and the safety devices of the electric hoist at the Curry shaft were briefly described in the Proceedings of the First Co-Operative Safety Congress held under the auspices of the Association of Iron and Steel Electrical Engineers at Milwaukee, Wis., Sept. 30 to Oct. 5, 1912.

Generating Power Plants.

After the success of electrical operation was assured, a second set of water wheels and generator was installed at the falls, for which provision had been made in the original design and in the construction of the foundations, and later three

* Presented also by mutual agreement at the meeting of the American Institute of Mining Engineers, February, 1914.

1 T. W. Orbison and F. H. Armstrong, Proceedings of the Lake Superior Mining Institute, Vol. xiii, pp. 153-181, (1908).

2 Frank H. Armstrong, idem, Vol. xvi, 244-250, (1911).

additional wires were added to the main transmission line, doubling its capacity and reducing the line loss.

The general conditions of this installation are particularly favorable for hydro-electric operation. In the neighborhood of three-fourths of the power used is for mine pumping, which in the main is regular and continuous. For air compressing, power is used for about 18 hr. a day for five days, and 9 hr. for one day in the week, though occasionally when shaft sinking is going on a very small amount of compressed air may be required continuously. Hoisting and surface tramming, which are intermittent, require only about 6 per cent. of the power used. The pond above the falls covers an area of about 450 acres and the head is 25 feet. There is, therefore, an ample quantity of water to take care of the ordinary irregularities of consumption without much change in the head, but on the other hand it does not supply any extended storage, as if the flow from above was entirely cut off the drawing down of 1 ft. would furnish water to supply the power requirements for only a little over 4 hours.

The power requirements of the mines, though somewhat variable, have been averaging about 2,400 h.p. The Menominee river furnishes this amount of power at what may be considered the normal stage. In dry seasons the water power has to be supplemented, and therefore a 1,500-kw. steam turbo-generator has been installed at the principal mine. This is sufficient in itself to take care of the pumping, if for any reason the hydro-electric plant should be out of commission. As a matter of fact, this has occurred without control only four times in six years, three times on account of anchor ice, not over 8 hr. at either time, and once for 3 hr. on account of a break in the transmission line due to a faulty disconnector. The protection against anchor ice is the length of the pond, which is about 5 miles to the next rapids above. As soon as this pond freezes over the anchor ice formed above does not come through. The three experiences with anchor ice were on days late in the fall before the pond had frozen over, when the temperature fell much below the freezing point and there was a high wind.

At the falls the generating units are of 1,500 and 2,000 kw., 6,600 volts, and are run singly or together according to the mine requirements and the quantity of water available. During the years 1911, 1912 and the first half of 1913, there was generated at the falls 37,502,160 kw.-hr. at a cost, including taxes, of 0.083c. per kilowatt-hour. The steam plant generated 1,670,700 kw.hr. at a cost, including stand-by expenses, of 1.821c. per kilowatt-hour. The average cost of power for operating was 0.157c. per kilowatt-hour. Depreciation for a 20-year period and interest at 5 per cent. add 0.182c., making the total cost, including operating, taxes, and depreciation, 0.339c. per kilowatt-hour.

At Republic the small water power is used entirely for compressing air. Electricity is used for the pumping, one surface tram, the crusher plant, and the shops. The principal generating unit is a mixed-pressure steam turbo-generator which runs on the exhaust steam of the hoisting engines supplemented by live steam. The exhaust steam is passed through a regenerator in order to distribute its use to as great an extent as possible during intermissions of hoisting. The successful utilization of intermittent supplies of low-pressure steam depends very largely on having the regenerator capacity of ample size. The steam turbine runs at 9,000 rev. per minute. Live steam is automatically supplied to fill any deficiencies in the amount of exhaust steam available. There is an independent condenser which produces a vacuum of 27 inches. Geared to the shaft of the steam turbine are two electric generators of a combined capacity of 150 kw., which run at 900 rev. per minute. These are to have fly wheels on the shafts so as to eliminate the peaks and reduce the heavy voltage fluctuations. Each wheel is 52 in. in diameter by 10 in. thick and weighs something over 5 000 pounds. The speed of the turbine when using live steam is 3½ per cent less than when using exhaust. These fly wheels will give, for this reduction in speed, 525 h.p.-sec. There is a back pressure on the hoisting engines varying from a maximum of 4 lb. to a slight vacuum. As close as can be figured, this turbine is furnishing a kilowatt-hour for a fuel cost of 0.15 cents.

Electric Pumps.

At the time when the original installation at Vulcan was under consideration, centrifugal pumps for high heads had not given good satisfaction in this country. There had been difficulties with thrust bearings and considerable doubt about continuous efficiencies. The correctness of the general mechanical principle of attaching a centrifugal pump directly to a high-speed motor was recognized. It was decided, therefore, to place the order for the main pumping units of centrifugal design under specifications to cover the principal requirements. In brief, these were for three units, each with an induction motor for 2,200 volts, 450 h.p., three-phase, alternating current, and a centrifugal pump in eight stages, four on each side of the motor, all on the same shaft, with a marine thrust bearing at each end, for a capacity of 900 gal. per minute at a speed of 1,200 rev. per minute, with suction lift of 20 ft. and discharge head including friction of 1,275 ft., with a combined efficiency of motor and pump of 63 per cent. Two of these units were put in at the West Vulcan C shaft and one at the East Vulcan No. 4 shaft. A

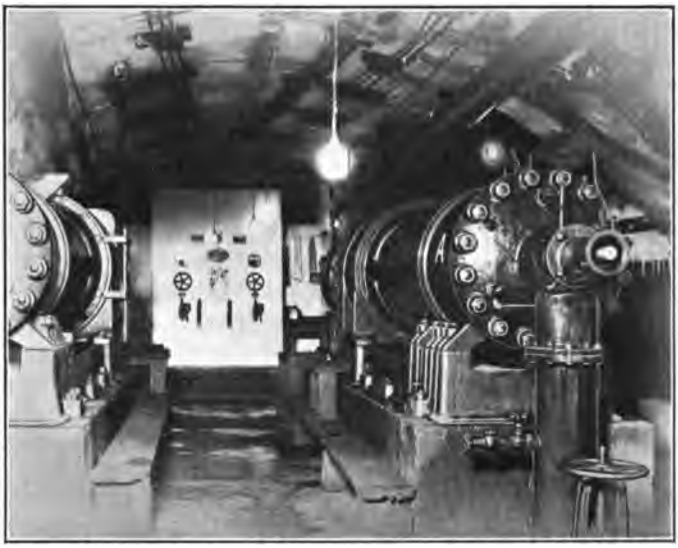

FIGURE 1 PUMP STATION AT WEST VULCAN

view of the two pumps at West Vulcan in the pump station 1,200 ft. below the surface is shown in Fig. 1.

When the pumps were started they fell short of the guaranteed efficiency; there was trouble from heat in the thrust bearings in starting, and rapid wear of the protecting sleeves about the shaft in the high-pressure stuffing boxes. The principal changes were in closing some holes in the impellers that had been made with the expectation that they would equalize the thrust movement; in substituting for the marine thrust bearing a hydraulic thrust ring against which the pressure of water in the column pipe is automatically applied by a slight thrust movement of the shaft; in some alterations to make it easier to change the wearing sleeves on the shaft; and in experimenting with different kinds of packing. The result of this work was the raising of the efficiency to the required standard, the elimination of all thrust trouble, and a reduction of the wear caused by the packing in the high-pressure stuffing boxes to very moderate proportions. Subsequently some further improvements were made.

Multi-stage centrifugal pumps consist of impellers attached to the shaft and stationary diffusion rings. The water enters an impeller near the shaft and issues with great velocity from its periphery. It then passes in a spiral direction through the passages of a diffusion ring to the inlet of the succeeding impeller or from the last impeller to the outlet. The expanding passageways for the water through the diffusion ring convert the velocity into pressure. The efficiency of a centrifugal pump depends principally on the shape and size of the impellers, the internal leakages, and the friction in the water passages.

The three original centrifugal pumps are made with a solid casing and the impellers and the diffusion rings are drawn out through the end of the casing. In the pumps installed since there is no casing, but the stationary parts of each stage are held together by large through bolts. None of the pumps have casings divided horizontally, which plan introduces unfavorable joints and necessitates disconnecting and lifting out the shaft and impellers. Without the horizontal joint the diffusion rings and impellers are very easily drawn out endways without disturbing the shaft. It takes about 4 hr. to take a pump of four stages apart and put it together again.

The experience of several years shows that there is very little wear in the interior or on the periphery of the impellers, or in the water passages leading from one impeller to another. The principal wear and the occasion of greatest loss in efficiency is between the impellers and the diffusion rings. Originally, the contact faces were quite narrow, only ⅞ in. They have since been made 1 7/16 in. and the tendency to leak has been decreased by using labyrinth rings, as shown in Fig. 2.

In later installations the hydraulic thrust ring was supplied with oil from a separate small motor-driven plunger pump. When oil was lacking it was found that water answered equally well. The advantage of having pressure independent of the water column is because the greatest tendency to thrust is on starting before the impellers become balanced, as they are when under the full head, because at the time of starting the column pipe may not supply the requisite or perhaps any pressure, and also because the independent pump gives a constant quantity at a variable pressure depending upon the thrust.

The main stuffing boxes were originally packed with a solid metallic packing, but, as that did not prove satisfactory,

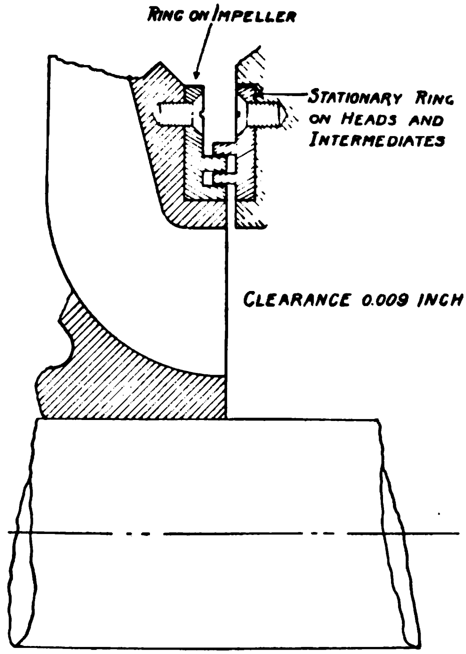

FIGURE 2 LABYRINTH RINGS TO DECREASE LEAKAGE

soft metallic packing and several kinds of special packings were tried in succession, but finally practice has settled down to a good grade of square braided hemp packing. The leakage is naturally greatest through the stuffing box on the discharge end of the pump, where there is the full pressure of 552 lb. to the square inch. As the shaft has only a rotary motion, when the packing is tightened up there is nothing to distribute the pressure applied upon the outside ring of packing to the other rings, as a shaft with motion lengthways helps to do, and consequently the outside ring is apt to be pressed so tight that it wears a groove in the shaft or the protecting sleeve about the shaft. No attempt is made to lubricate the packing. The shaft is protected from this wear in the stuffing boxes by removable sleeves. It takes only 2 hr. to replace a sleeve. The replacing of the sleeves has been the greatest source of delay of a mechanical nature, but the aggregate of the delays is very small. At the East Vulcan mine, where for nearly three years there was only one electric centrifugal pump, and it was run as nearly continuously as possible, the total delays amounted to only 364 hr. in 33 months, or less than 1½ per cent. of the time.

Occasionally the discharge of the pump has fallen off, due to chips or refuse in the suction end of the pump. This is guarded against as much as possible by having duplicate wire screens in the suction tank, so that all the water from the mine has to pass through a screen. The screens are in duplicate, so that there may always be one in place when the other is raised for cleaning. In these mines it has been found that the best protection against grit in the water is to be had from good ditches which keep the water in the drifts below the traveled road. The internal wear of the water passages due to grit has been exceedingly small. The water is free from acid and without corrosive effect. The internal construction of these pumps is simplicity itself, and their dependability is much greater, and the time and cost of repairs much less, than with the triple-expansion steam pumps which the centrifugals displaced.

Approximate figures on the maintenance for one year of four centrifugal pumps as compared to four triple-expansion steam pumps doing practically the same duty are as follows:

	Centrifugal.	Steam.
Shop labor	$ 717	$ 760
Labor on pumps	690	590
Supplies	503	2,021
	$1,910	$3,371

The motor of these pumps have wound rotors with a device for short circuiting the secondary current and relieving the brushes from wear by lifting them from the rings. These pumps were rated at 900 gal. per minute and that was about the quantity of water that they handled at first. Soon after the quantity to be pumped increased to 1,100 gal. per minute. This was too much for one pump and not enough for two, so that it was necessary to start and stop one pump frequently.

As this quantity of water continued for some time, it was found that by increasing the speed of the generators at the falls from 60 to 62½ cycles per second, the pumps were each capable of handling from 1,200 to 1.300 gal. per minute. This overloaded the motors, and after running for a consid-

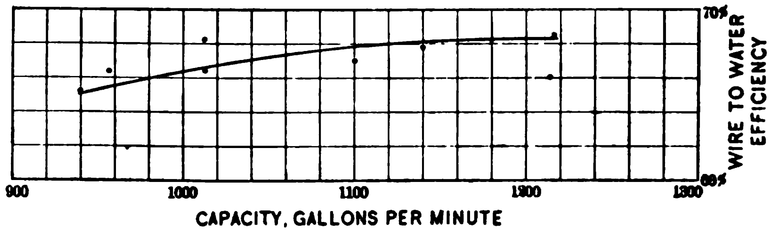

FIGURE 3 EFFICIENCY CURVE OF 8-IN. EIGHT-STAGE CENTRIFUGAL PUMP

erable time it was found that the insulation had been baked until it was brittle. This made trouble when it became necessary to repair the windings. A dropping off in efficiency will also overload the motor, so that it is well to have centrifugal-

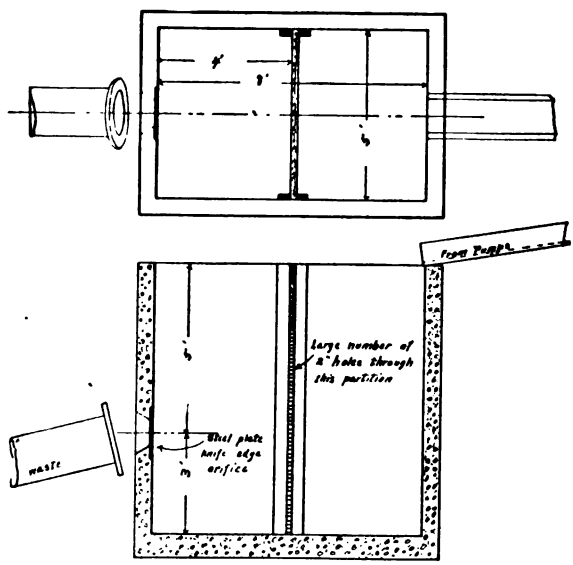

FIGURE 4 MEASURING TANK

pump motors of a larger size than the specified head and quantities under normal conditions call for.

Fig. 3 shows an approximate curve of efficiency based on eight tests at different quantities on a pump when in first-class condition. During these tests the unit was being run at 1,235 rev. per minute and the quantity was varied by manipulating a valve on the suction.

In order to test the efficiency of the pumps it was necessary to measure the water. At first, this was done on surface, by means of both a tank with knife-edged orifice and a weir. Permanent concrete tanks were later installed at both East Vulcan and West Vulcan so as to obtain a continuous record of the amount of water pumped. One of these tanks is shown in Fig. 4. There is a division wall in it which is pierced with a great many 2-in holes. The water from the mine flows into the back part of the tank and through the holes in the division wall into the front part of the tank. This breaks up the flow of water and prevents "velocity of approach" to the orifice. In the front wall of the tank there is a plate of steel with a circular knife-edge opening of exact size.

The quantity of water that flows through the orifice depends on the head above the center of the orifice. The head is recorded on a recording water-level guage and tables for each orifice show the gallons per minute corresponding to each tenth of a foot of head. One of the charts is shown in Fig. 5. This chart was used in connection with an orifice having a diameter of 7 in. and shows an average for the week of about 894 gal. per minute. When the pumping is irregular the average is ascertained by the use of a planimeter for circular charts. On this chart it can be seen that the pumps were stopped for a few minutes three times during the week. The charts are changed Sundays at noon. Orifices of different sizes are used when the quantity of water changes, so as to keep the water at somewhere between 2 and 4 ft. above the center. With these permanent measuring tanks and suitable electrical instruments a test of efficiency becomes a very simple matter.

At the Brier Hill shaft, where there are only from 30 to 40 gal. per minute, and a depth of 900 ft., there is a motor-driven reciprocating, horizontal, plunger pump, of 125 gal. per minute capacity, which on Sundays and holidays may be operated from the hoist house on surface, the high- and low-water mark in the sump being provided with an electric signalling device to the hoist house.

At the Republic mine, for pumping from a depth of 1,150 ft. a motor-driven triplex plunger pump of 95 gal. per minute and a motor-driven horizontal duplex plunger pump of 125 gal. per minute are used, but at that point the maximum water is only 150 gal. per minute, with an average of about 50 gallons. At other points where the quantities are moderate and intermittent operation is not objectionable, motor-driven plunger pumps are used.

In the smaller sizes centrifugal pumps are inefficient, but the efficiency increases with the size. Pumps of 600 to 1,200

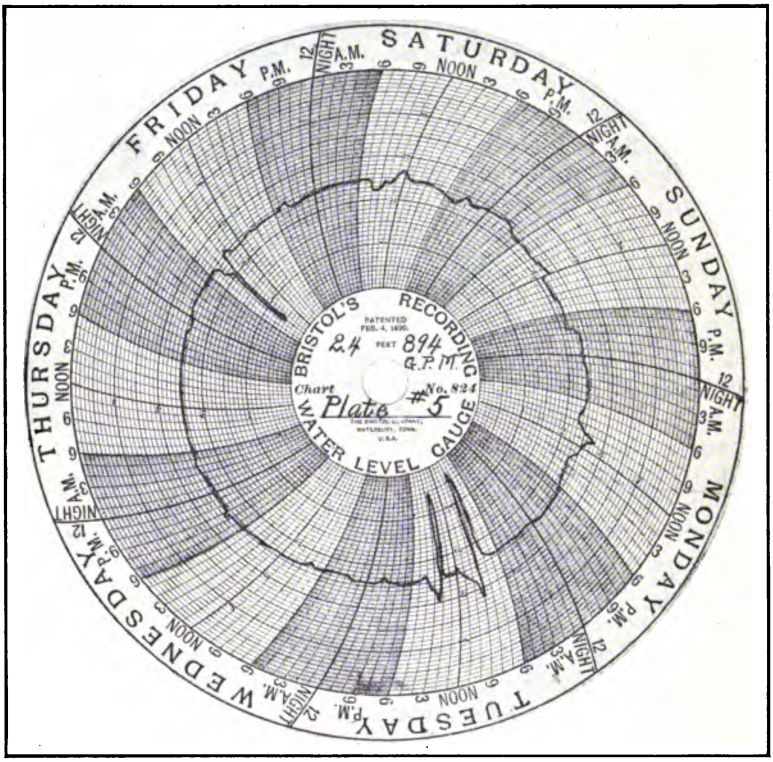

Figure 5 Chart From Recording Water-Level Gauge

gal. a minute can be easily maintained at an efficiency of 55 to 65 per cent. measured from the power delivered to the motors to the water at the top of the shaft, while pumps of larger capacity will undoubtedly give higher efficiencies.

One of the great advantages of centrifugal pumps is that the quantity of water can be regulated within comparatively wide limits by simply opening and closing a valve on either the suction or the discharge pipe, preferably the former, with but slight variation in the efficiency. A reciprocating pump driven by an induction motor, on the other hand, must run at a constant speed. Mechanical devices to change the speed of the pump or the quantity of water per stroke are necessarily complicated. The common practice for decreasing the quantity is to use a by-pass on the discharge column, allowing a portion of the water to return to the sump. This of course is directly at the expense of efficiency. Intermittent pumping necessitates adequate sump capacity. It may be generally said that a reciprocating pump driven by an induction motor is especially suited to pump a certain amount of water against a head that may be varied at pleasure, while with a centrifugal pump the quantity of water can be regulated but the head cannot be materially changed without structural changes. To effect the latter end a centrifugal pump should be designed for changing either the number or the diameter of the impellers. High-pressure centrifugal pumps are usually designed for a head of 100 to 150 ft. for each stage or impeller. The speed must be approximately 1,200 or 1,800 rev. per minute with a six- or four-pole motor and a 60-cycle alternating current. With a 25-cycle current the speed would not be sufficient, except with a two-pole motor.

Electric Hoists.

Before the introduction of electricity, hoisting at the Penn mines was done at five shafts with steam hoists of the following types:

Shaft	No. of Drums	Diameter feet	Geared	Position of Drums
East Vulcan No. 4	2	10	Yes	Tandem
East Vulcan No. 3	2	5	Yes	On same shaft
West Vulcan C	2	12	Yes	Tandem
West Vulcan C	2	12	No	On same shaft
Curry No. 1	2	6	Yes	On same shaft
Norway No. 10	2	5	Yes	On same shaft

The principal hoisting was at East Vulcan No. 4 and West Vulcan C shafts. The geared plants at these two points were altered so as to permit their being driven by motors. This was done by extending the pinion shaft on the side opposite to the steam engine and putting on the extended shaft a large rope wheel, which was driven by an American system rope drive from a small rope wheel on the shaft of the motor. On the other side the connecting rod of the steam engine was disconnected. This arrangement is illustrated in Fig. 6. The method of operating is to start the motor, rope wheels, gear wheels, and drum shafts and when these are up to speed gradually to apply the clutch of the drum, thus starting the skip or cage and quickly accelerating it. This had always been the practice in starting with steam except that with the rope wheels and motor the fly wheel effect is greater.

At the same time the East Vulcan No. 3 hoist, which was used very intermittently and principally for depths of only 250 ft., was run by compressed air generated by a motor-

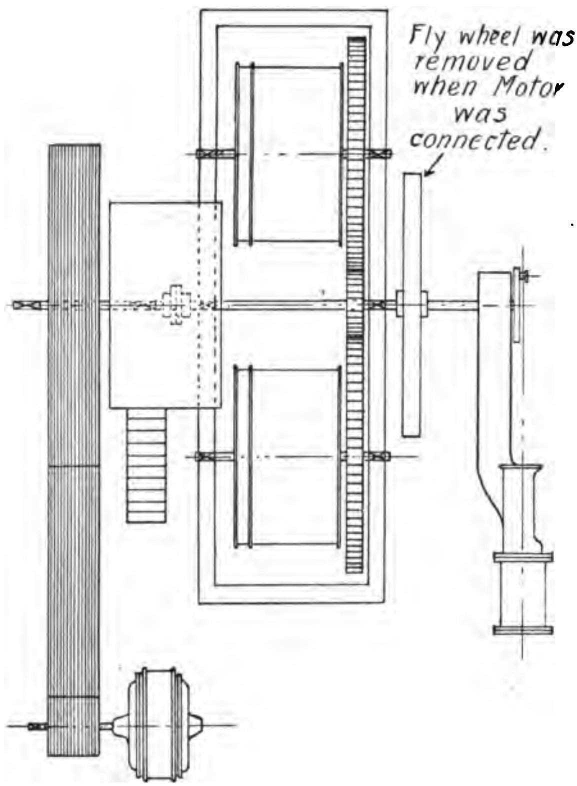

FIGURE 6 TANDEM DRUMS DRIVEN BY EITHER ENGINE OR MOTOR

driven compressor. As the work of this hoist has increased a motor and belt have been substituted for the engine, as shown in Fig. 7. The same change was made with the Norway hoist. The first-motion steam hoist at West Vulcan has been dispensed with. The Curry hoist was formerly run by steam from the saw mill. This hoist was too small for the work and has been replaced by a new electrically driven plant. A new hoist has also been supplied for the circular concrete-lined shaft at Brier Hill. These last two hoists will be described more in detail.

The motors of the four principal hoists are all of standard design. They are three-phase, 60-cycle, 2,200-volt induction motors with wound rotors and external resistance for starting.

Experience shows that the motors at West Vulcan, Curry,

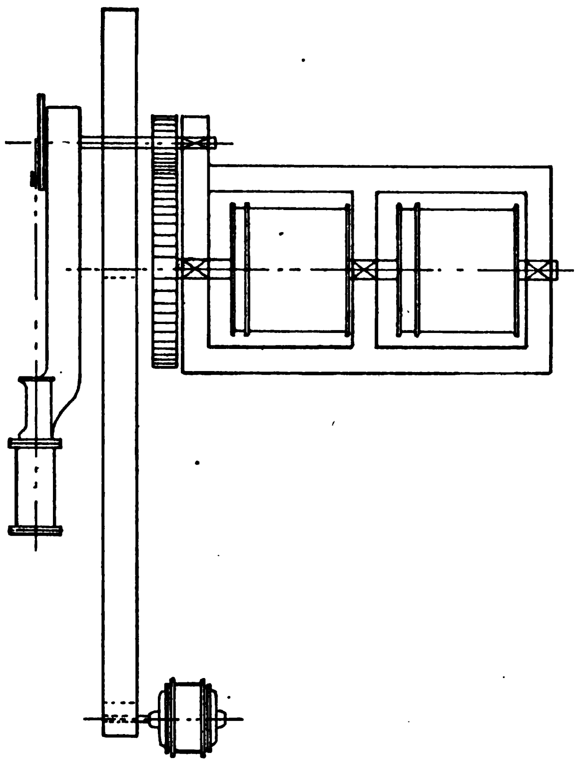

FIGURE 7 PARALLEL DRUMS DRIVEN BY EITHER ENGINE OR MOTOR

and Brier Hill are much larger than is required. A motor of 200 h.p. would be sufficient for the requirements of any of the above shafts.

	Horse-power	Revolutions Per Minute	Skip Load Pounds	Present Maximum Travel of Skip	Speed of Skip or Cage per Minute, Feet
East Vulcan No. 4	220	360	6,700	1,557	590
West Vulcan	350	360	6,000	1.546	588
Curry	350	360	12,000	1,410	600
Brier Hill	450	300	12,000	989	600

The first hoist at these mines constructed solely for electric hoisting was installed at the Brier Hill shaft. This hoist has two drums with shells of steel plate 12 ft. in diameter by 5 ft. 9 in. face, and 2 cast-iron conical drums, of which the small diameter is 4 ft. 6 in. and the large diameter 17 feet. These drums, Fig. 8, are keyed on two parallel shafts, a cylindrical and a conical drum on each shaft. Each cylindrical drum is driven by a Lane friction clutch from a cut spur gear having 144 teeth, 4-in. circular pitch and 12-in. face. The pinion has 46 teeth, giving a gear ratio of 3.13 to 1. On the pinion shaft is a rope wheel 21 ft. 6 in. in diam-

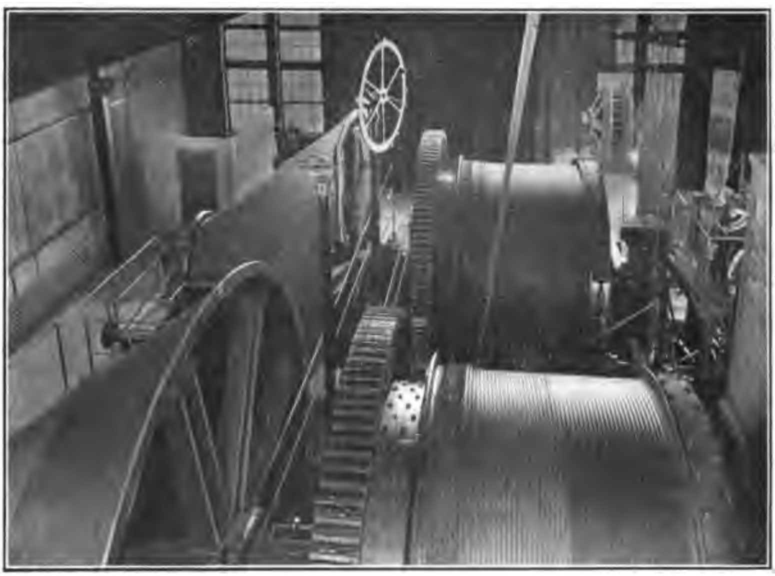

FIGURE 8 HOIST AT BRIER HILL SHAFT

eter. having 24 grooves for 1¼ in. manila rope. The pulley on the motor is 48 in. in diameter. The friction clutches and band brakes are operated by compressed-air cylinders each having an oil cylinder to prevent jumping and to hold it at any point. Safety devices on this hoist fulfill the same conditions as those on the Curry hoist, but are more complicated and will not be described in detail here.

Before putting in this plant it was thought that a hand-operated controller for so large a motor as 450 h.p. would be hard to handle, so an automatic controller operated by alternating-current solenoids with a master controller was installed. This controller required frequent attention and was very noisy. It has been replaced with a water rheostat, which after some experimenting was built as shown in Fig. 9. The tank is of concrete, open on top and nearly full of a weak solution of carbonate of soda. A timber crosshead is suspended above the tank and to the under side of it four iron plates are attached. The plates are connected to the three secondary leads from the motor as indicated in the drawing. The crosshead and plates are raised and lowered by a rope

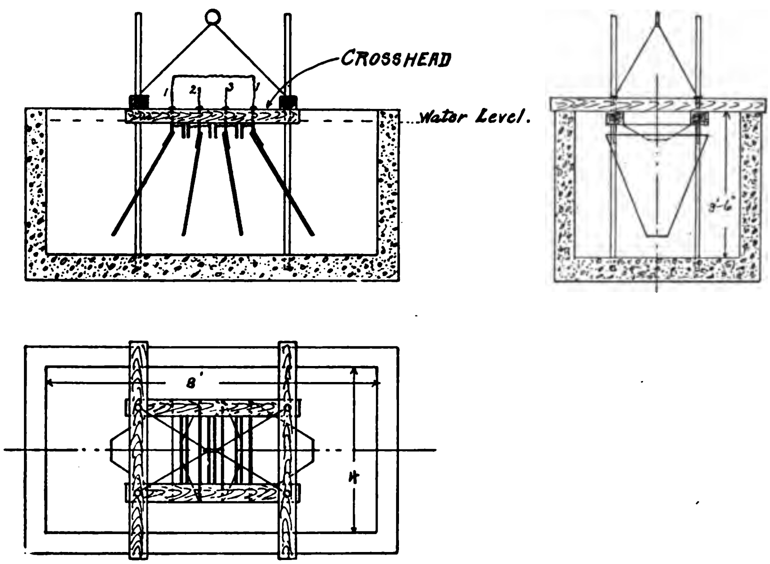

Figure 9 Water Rheostat Controller for 500-h.p. Induction Motor Hoist Service

which leads from an air cylinder in the hoist house. The plates are trapezoids in shape with the shortest side down and they are set at angles to each other so that the lowest parts are the greatest distance apart. As the plates descend into the water the areas increase rapidly and the parts at the surface of the water are closer together, so that the electrical resistance is reduced. The setting of the plane of the plates at an angle with the perpendicular also stirs up the solution to some extent. Between each pair of plates are smaller plates much closer together, electrically connected to the large plates, and at such a height that they enter the water just as the large plates become completely submerged. By adjusting the distance between these small plates the amount of slip of the motor when pulling full load at full speed can be varied.

The mechanism for regulating the speed with which the plates are lowered into the water, for raising the plates out of the water, and for operating the primary switch is shown in Fig. 10. A four-way valve having only two positions, "on" and "off," is handled by the operator. In the "on" position air is admitted to a small cylinder which closes the primary switch, and the pipe leading to the air cylinder is opened to exhaust. The weight of the crosshead and plates causes them to sink into the water at a speed determined by the amount of opening of the by-pass valve on the oil cylinder. When the

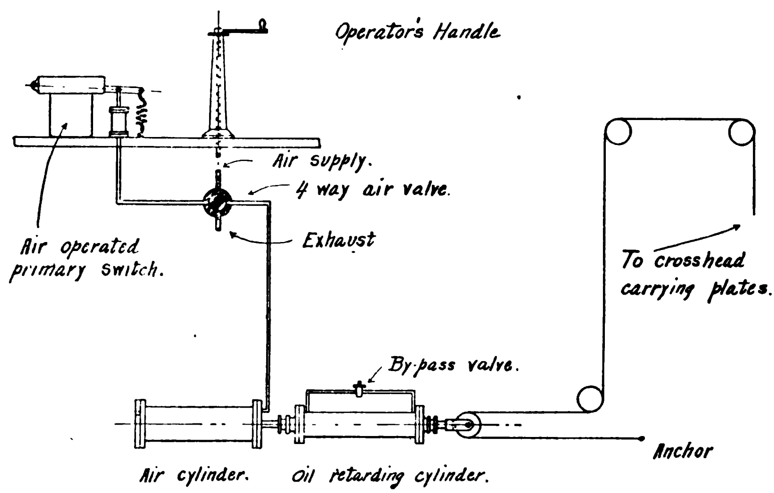

FIGURE 10 OPERATING MECHANISM FOR WATER RHEOSTAT

hoist is nearly completed the operator throws the handle to the "off" position. This allows the air in the primary switch cylinder to exhaust, thereby opening the switch, and at the same time admits air into the air cylinder, thus raising the plates nearly out of the water.

Fig. 11 shows the starting curve with this water rheostat. Fig. 12 shows the corresponding curve with the automatic controller previously used. On comparing these it will be seen that acceleration was accomplished with the water rheostat in 20 sec., while it took 40 sec. with the automatic controller, and the power drawn from the line was much more uniform with the former. The curve in Fig. 11 also shows the practically perfect counterbalancing of the skip and the unbalanced load of the cage.

The Curry hoist, shown in Fig. 13, was designed and built by the Penn Iron Mining Company. It has been in service since March, 1912. It has two cast-iron drums 12 ft. in diameter by 6 ft. face on the same shaft, each drum having a band brake 10 in. wide, 12 ft. in diameter, and driven independently by a Lane friction clutch 12 in. wide, which grips a friction ring 10 ft. 4 in. in diameter.

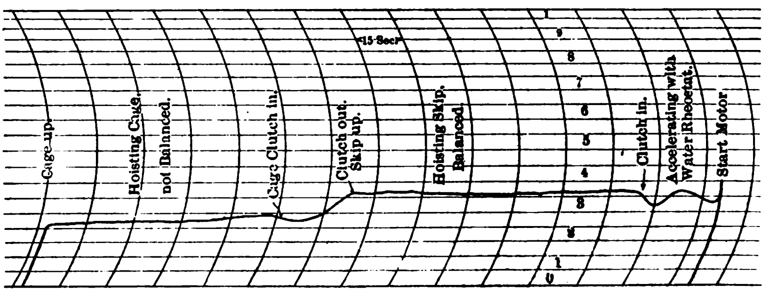

FIGURE 11 STARTING CURVE WITH WATER RHEOSTAT

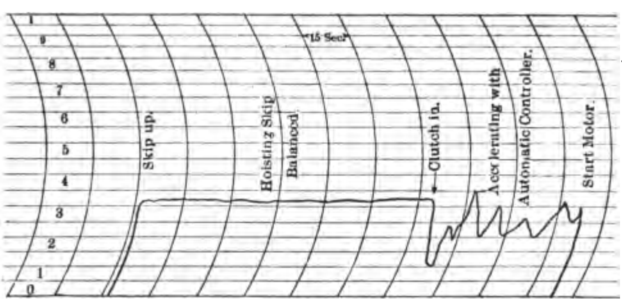

FIGURE 12 STARTING CURVE WITH AUTOMATIC CONTROLLER

The main shaft is driven by a Falk cut helical gear having 181 teeth, 1¼-in. circular pitch, and an 18-in. face. The pinion meshing with this gear has 19 teeth, giving a gear ratio of 9.52 to 1. On the pinion shafts is a rope wheel 9 ft. 10 in. in diameter having 24 V-grooves for 1¼-in. manila rope. The rim of this rope wheel is 3⅛-in. thick, to give it the proper amount of inertia. This rope wheel is driven from the 350-h.p. motor by a rope pulley 50 in. in diameter.

The friction clutches and band brakes are power operated. In the basement is a small motor-driven triplex pump which takes oil from a suction tank and pumps it into a pressure tank. When all the oil in the system is in the pressure tank it is only one-third full of oil, two-thirds of the volume being compressed air at 80 lb. gauge pressure. As fast as oil is used and exhausted into the suction tank the pump puts it back into the pressure tank. When there is no oil in the suction tank the pump draws air, which is compressed and delivered into the pressure tank. A small safety valve allows

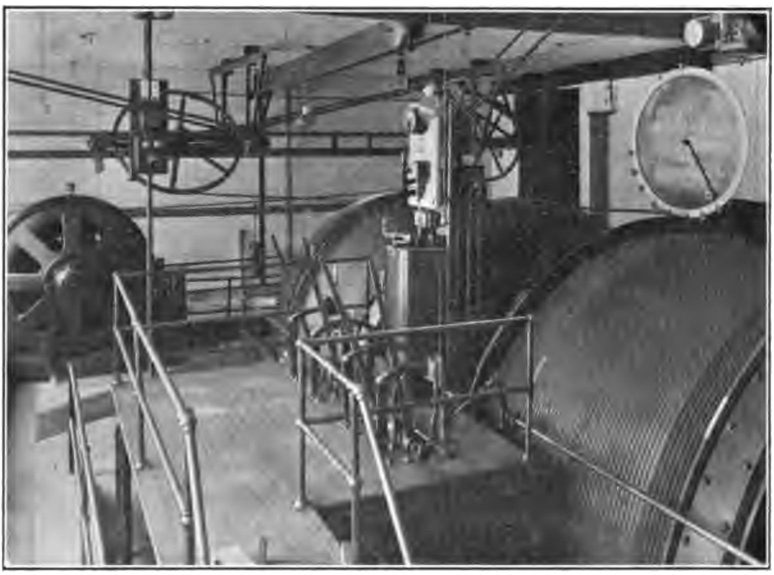

FIGURE 13 HOIST AT CURRY SHAFT

the escape of any excess air. The brake is released by an oil cylinder and set by a weight, oil being admitted or exhausted by a three-way valve. The hand lever operating this valve is connected differentially to the brake lever so that the brake follows the operator's hand. The clutch is engaged by oil cylinder and released by a weight in the same manner. The use of oil under pressure instead of compressed air or steam insures smooth action of the clutch and brake, making sudden starting or stopping almost impossible, while the use of weights to release the clutch and set the brakes insures a reliable source of power for stopping.

The safety device stops the drum under any one of four conditions, viz: Lowering too rapidly; overwinding; at a point 90 ft. above the bottom when lowering; and at a point 50 ft. below the surface when coming up. The two latter stops are under the control of the brakeman, so that if he is aware of the position of the cage or skip he can disconnect either of these two devices. Referring to Fig. 14, the levers which operate the valves of the clutch and brake cylinders are shown, one in the "running" position and one in the "stop" position. A solenoid is arranged to release a weight which puts both clutch and brake levers into the "stop" position.

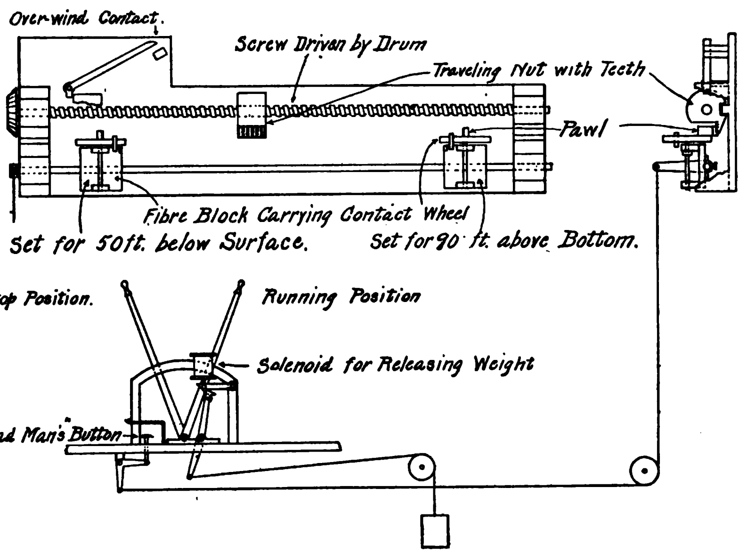

FIGURE 14 SAFETY DEVICE ON HOISTS

It remains then to have a contact made that will send a current through the solenoid when it is desired to stop the drum. The contact for stopping when lowering too rapidly, the condition first mentioned, is made by a simple fly ball governor, shown in Fig. 15. The other three conditions are controlled by means of the device shown in Fig. 14. A screw, driven by the drum, carries a nut with teeth which strike a pawl on the contact wheel, turning the wheel slightly and thus making a contact. By slightly turning the shaft which carries the contact wheels, the pawls are lifted and the nut travels under without turning the wheel. The shaft may be turned by pressing on the "dead man's button." The contact for the overwind needs no description. Fig. 15 gives a general view of this safety device. This device has been tried many times and all of the four conditions have always been met.

The ore formations at Vulcan are inclined at varying angles from 45 to 90 degrees from the horizontal, but all the shafts are vertical with the exception of the lower part of

FIGURE 15 FLY-BALL GOVERNOR FOR SPEED CONTROL

East Vulcan No. 4. The orebodies are very irregular in shape and may be considered ore shoots rather than lenses. The quantities on different levels vary greatly. For this reason hoisting with independent drums rather than with drums in balance presents advantages. A single drum at any of the shafts will carry all the ore required and work more or less intermittently. This economizes shaft space, and with a plant of two drums one can be used for a skip and the other for a cage.

In the important installations the weight of the skips, and when heavy the weight of the cage, is counterbalanced by a weight in the shaft. The road for the counterbalance requires very little space in the shaft, as the counterbalance is made fairly long and small in the other directions. In one case an old Cornish pump plunger 16 in. in diameter and 10 ft. long partly filled with scrap has been used.

At East Vulcan No. 4 and Curry, in order to balance and equalize the weight of the ropes, the counterbalance rope, after leaving the hoisting drum, passes outside of the hoisting house to one of two connected conical drums toward its smaller

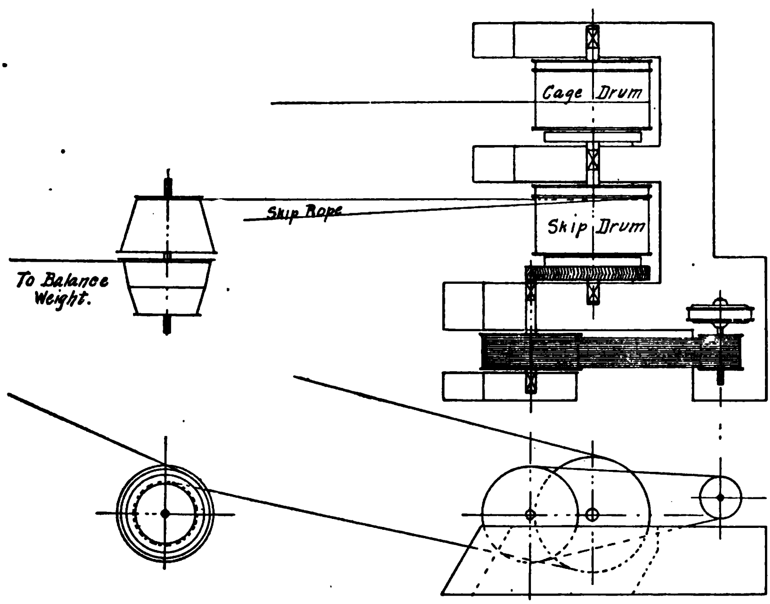

FIGURE 16 ARRANGEMENT OF CURRY HOIST AND BALANCE DRUMS

diameter, while from the larger diameter of the other drum another rope leads to the shaft and carries the counterweight, as shown in Fig. 16. The uniformity of the balancing throughout the travel of the skip in the Curry hoist is shown in Fig. 17. In the Brier Hill plant, instead of the pair of conical drums outside the hoisting house there is a conical drum on the shaft with each of the main hoisting drums and the counterbalance rope leads from the smaller end of the conical drum (see Figs. 8 and 18.) This arrangement is possible only when the hoisting drums are set tandem to each other. The strains on the counterbalance drum are so much less than on the hoisting drum that it can be very much lighter and there are fewer difficulties in its structural features than where conical drums are used for hoisting. The counterbalancing of

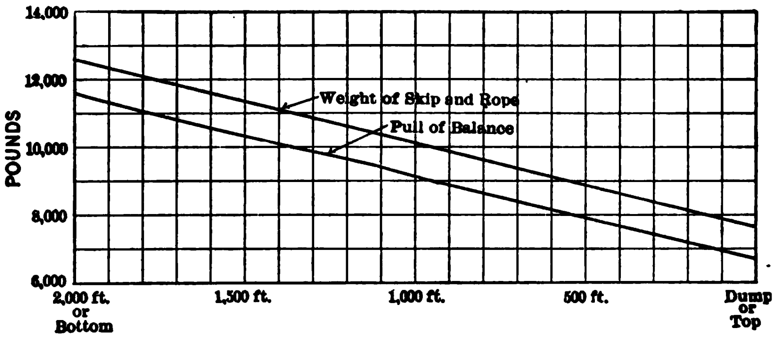

FIGURE 17 CURVES SHOWING VARIATION IN BALANCE WITH CURRY BALANCE DRUMS. 1¼-IN. HOISTING ROPE, 4,900 LB.; SKIP WEIGHS 7,600 LB.; WEIGHT OF COUNTERBALANCE 8,260 LB.

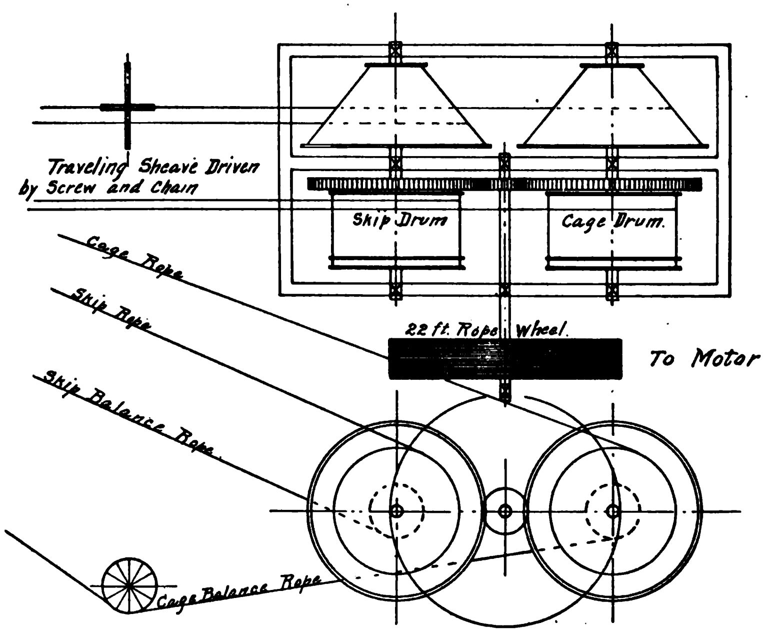

FIGURE 18 ARRANGEMENT OF BRIER HILL BALANCE DRUMS

the ropes by means of a single conical drum necessitates the use of a drum with a wide difference between its end diameters, a difference which in some cases is almost impracticable, and in any case requires deep grooving. Such a drum is more expensive both for itself and for the inclosing building than the pairs of drums used on the other plants and is heavier, thereby increasing the inertia.

In order to equalize the weight of the ropes in every part of the shaft as nearly as possible the angle of the cones must be carefully designed. To obtain absolute equalization would require a cone of which the outlines of a longitudinal section would be curved rather than straight, but the difference in counterbalancing effect in different parts of the shaft can usually be kept within 100 or 200 lbs. with straight cones.

In thus counterbalancing the dead weights some allowance must be made so that the descending skip will overhaul the drums. This requires generally an unbalanced load of not exceeding 800 lbs. The excess of weight of the empty skip or cage should only be such as to take it down with little or no application of the brake for the greater part of its travel. In a shaft 2,000 ft. deep, where the weight of ore hoisted is 12,000 lb., the weight of the skip 7,400 lb., and the rope 4,900 lb., or a total dead weight of 12,300 lb., the loss, neglecting friction, would be 50.6 per cent. When the dead weights are counterbalanced to within 800 lb. the loss is only 6.6 per cent.

In this method of counterbalancing the conical drums have been designed so that the total travel of the counterbalance will be so much less than that of the skip or cage that the counterweights will never come to the surface when the skip or cage is at the bottom of the shaft. This has been done to avoid the freezing of the counterweight to its guides in severe winter weather.

For a counterbalance recently designed for one of the Republic shafts, in place of the two conical drums there are a nearly cylindrical drum and a reel for a flat rope which carries the counterweight. This method of counterbalancing can be used for a depth of at least 3,000 ft. in a vertical shaft with a load of ore of 12,000 lb., as illustrated in Fig. 19. In Fig. 20 is shown the uniformity of the balancing.

When a skip is in the dump a part of its weight rests on the members of the headframe and it is necessary to make some compensation so as to maintain the equalizing of the weights at that point as well as at other points in the travel. This has been accomplished in several ways. One way was to have the counterweight made in parts, the upper part of larger cross section than the lower part, so that when the skip was entering the dump the larger part of the counterweight near the bottom of the shaft would be caught on stationary projections from the shaft timbers and held there, to be caught

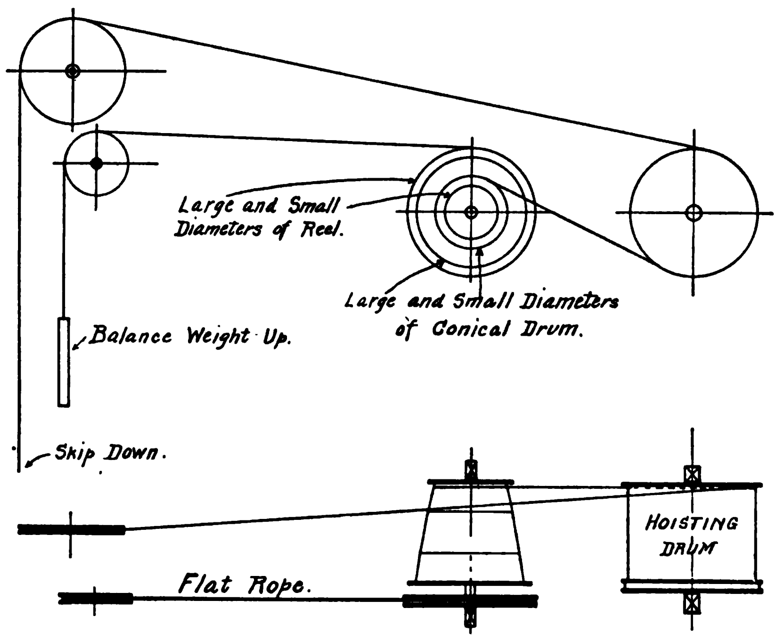

FIGURE 19 METHOD OF COUNTERBALANCING FOR 3,000-FT. VERTICAL

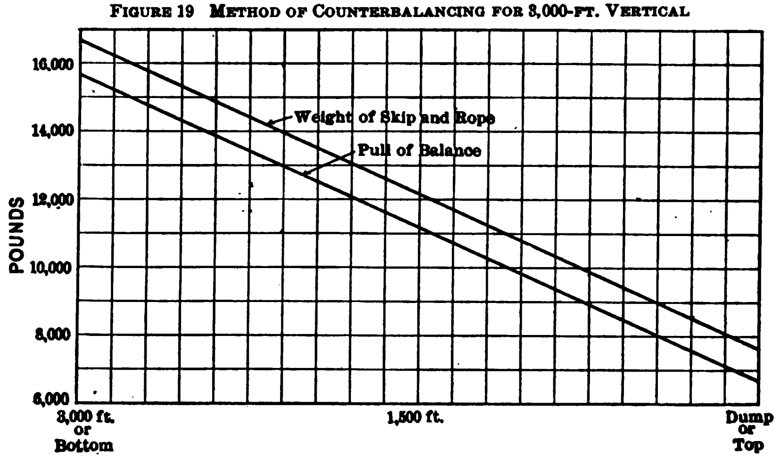

FIGURE 20 CURVES SHOWING VARIATION IN BALANCE WITH WHEEL AND DRUM. 1⅛-IN. HOISTING ROPE, 9,000 LB.; ⅝ BY 2½-IN. FLAT BALANCE ROPE, 5,100 LB.; WEIGHT OF SKIP 7,600 LB.; WEIGHT OF BALANCE, 8,400 LB.; LOAD RAISED (ORE), 12,000 LB.

up again when the skip came out of the dump. Even with slowly traveling ropes this put on a sudden strain which was not desirable. Another method that has been used is to curve the counterweight road at the bottom so that the vertical component of the weight decreases similarly to that of the skip when it goes into the dump. This answers the purposes excellently, but the curved road requires additional rock excavation in the mine and is expensive to build and maintain.

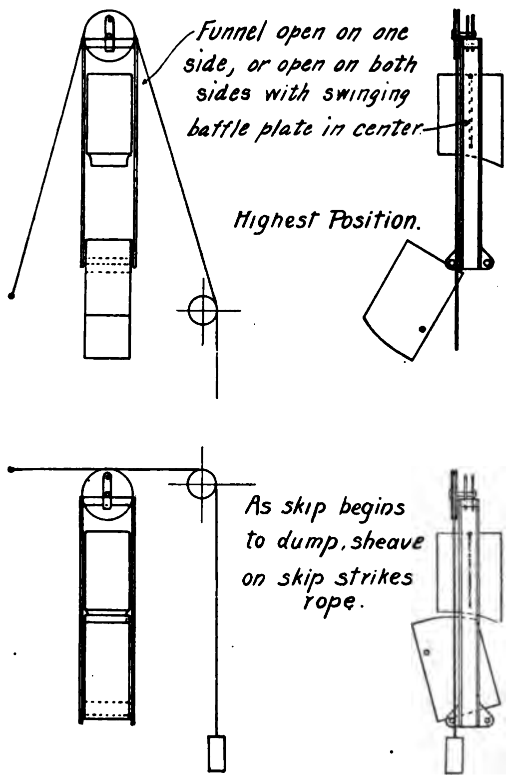

FIGURE 21 "TAKE ON" BALANCE

Also, when new levels are sunk the location of the curve must be changed. No attempt has been made to make this equalization by change in diameters on the conical drums, for like reason. The method which has proved to meet the conditions most satisfactorily is to have the frame of the skip pick up a weight as the box goes into the dump. In order to take the weight gradually and without jar, an idler wheel

36 in. in diameter attached to the top of the bail of the skip engages a rope which lies across the skip compartment just as the box of the skip starts into the dump. One end of the rope is fixed, the other end passes over a vertical wheel and has a weight attached to it. The weight does not hang over the shaft and a fence prevents any one from getting under it. Without this "take-on" balance or a similar device it would not be possible to have the counterweight in the shaft as heavy as it might otherwise be by several hundred pounds. (See Fig. 21.)

The use of a counterweight with independent skips and cages not only reduces the total work but makes the work after the moving parts are up to speed equal throughout the whole of the travel. In hoisting with skips in balance, unless there is a tail rope the weight of one of the ropes is added to the required starting torque, gradually decreases, is balanced half way up and thereafter increases negatively.

In the system of hoisting described the extra power required to start the skip or cage and accelerate it is provided for in the fly-wheel action of the revolving parts, especially in the larger rope wheel. The design is based on the requirement that the energy stored is sufficient to accelerate the load without reducing the speed below the slip speed of the motor. In this method no resistance is required to reduce the speed, as in the Ilgner system, and that loss is eliminated. The drums are controlled mechanically by means of a clutch and a brake in the same way that has been in general practice for years with steam plants of like design. If built with ample surfaces the clutches and brakes are effective and require very little attention. The Brier Hill hoist was started in April, 1910, and has run three years and seven months, hoisting during that time 500,000 tons of ore. The original frictions are still in service. The Curry hoist has run 20 months and hoisted 150,000 tons without requiring a replacement of the frictions. When the counterweights are used the brakes also require very little attention. The control of a drum by means of a mechanical clutch and brake is as simple and exact as can be desired.

This system has the same advantage as the Ilgner system in the fly-wheel action to prevent any peak load in starting the drum, but the fly-wheel effect is limited to what is sufficient for that purpose and is not intended to provide power to hoist much after the power is shut off. As hoisting at these mines is generally intermittent the practice is to start up the motor when the signal to hoist comes in. It takes about 20 sec. to get it up to speed. Before the skip or cage reaches the top the current is cut off and the travel is completed by means of the momentum of the moving parts. The motor is then idle until there is another call to hoist. When hoisting is irregular the saving over the Ilgner system by not having to keep a heavy fly-wheel in motion is considerable. There is also a considerable saving in the mechanical control over the Ilgner control by the omission of the direct-current generator and motor. There is some loss, however, in the mechanical appliances of a clutch and brake, but these probably do not equal the rheostat losses of the other system. It must be admitted that no power can be derived from lowering timber, men, tools and other weights, as in the case of the Ilgner system or with a compressed-air system such as has been recently installed at Butte and described in B. V. Nordberg's paper entitled The Compressed-Air System of the Anaconda Copper Company.[3] No continued record at the Penn mines is available for these lowered weights, but a careful record for a week at one shaft, at which the greatest amount of timber is lowered, shows that the lowered weights are 5.67 per cent. of the weights hoisted. Only a small fraction of this loss could be recovered by either the Ilgner System or the compressed-air system at Butte. The total weight lowered at Brier Hill in a week is less than 250 tons, a distance of 750 ft., and the power wasted costs only 47c to generate.

The following figures show the results of tests of hoisting at the Brier Hill and Curry shafts. By "live ton-feet" is meant the live load of ore in tons multiplied by the number of feet hoisted vertically.

RESULTS OF TEST ON BRIER HILL ELECTRIC HOIST.

Date Nov. 1911	Kilowatt hours	No. of Tons Hoisted From 5th Level	6th Level	8th Level	9th Level	Live Ton-feet	Kilowatt-hours per Live Ton-foot
6	563	6	24	195	228	371,424	0.001515
7	578	3	33	183	249	384,579	0.001505
8	558	3	30	180	240	372,480	0.001497
9	597	9	36	168	270	396,162	0 001507
10	615	6	30	183	279	410,853	0.001496
11	287	0	12	75	141	190,671	0.001510
Total	3,198					2,126,169	0.001504

From the 5th level to the dump is 480 ft.; 6th level, 592 ft.; 8th level, 780 ft.; 9th level, 887 ft. Load, two cars or 12,000 lb. of ore. Hoisting speed, 600 ft. per minute.

3 Bull. No. 81, Sept., 1913, p. 2225. A. I. M. E.

It takes at the rate of 2.256 kw.-hr. to hoist 1 ton of ore 1,500 ft. and the cost of power for this work is 0.764c.

RESULTS OF TEST ON CURRY ELECTRIC HOIST.

Date June 1912	Kilowatt hours Integrating Meter	—No. of Tons From— 16th Level	17th Level	Live Ton-feet	Kilowatt-hours Per Live Ton-foot
12	243.75	117	12	169,956	0.001434
13	462.5	210	36	325,440	0.001421
14	481.25	243	18	343,224	0.001402
17	450	258	3	341,694	0.001318
18	456.25	216	24	316,368	0.001442
19	462.5	228	21	327,834	0 001411
20	462.5	222	18	315,756	0.001465
	3,018.75			2,140,272	0.0014104

From the 16th level, 1,308 ft., to the dump; 17th level, 1,410 ft. Hoisting speed, 600 ft. per minute. Load, two cars or 12,000 lb. of ore.

It takes at the rate of 2.1156 kw.-hr. to hoist 1 ton of ore 1,500 ft. and the cost of power for this work is 0.712c.

On a capacity test recently made on the Curry hoist 13 skips, or approximately 78 tons, of ore was raised 1,410 ft. in 61 min. This is equivalent to 325,000 to 350,000 tons a year.

From data collected during this test it has been estimated that with a hoisting speed of 1,200-ft. per minute, which is well within safe limits, an output of 300,000 tons per year could be obtained from a depth of 3,000 ft., and greater quantities at less depth. In addition to the very high efficiency of this system of hoisting, the comparatively small cost of the hoisting plant and accessories, the saving in the size of the building to inclose it and the decreased space required in the shaft must be considered.

ELECTRICALLY DRIVEN AIR COMPRESSORS.

In substituting electrical for steam machinery at the Vulcan mines four compressors were installed. At East Vulcan the compressor is two-stage, having a capacity of 2,200 cu. ft. of free air per minute at a speed of 120 rev., driven by a rope drive from an induction motor of 350 h.p., 2,200 volts at 360 rev. per minute. At West Vulcan two two-stage compressors were put in. Each has a capacity of 3,300 cu. ft. of free air per minute, runs at 72 rev. per minute and is driven by a rope drive from an induction motor of 450 h.p., 6,600 volts at 300 rev. per minute. At Norway a straight-line, two-stage compressor of 780 and 390 cu. ft. of free air per minute was changed by removing the steam cylinder, putting a belt wheel on the main shaft and driving it from a two-speed induction motor of 100 h.p., 2,200 volts at 600 and 300 rev. per minute. The use of rope drives for the larger compressors and a belt for the small one permitted the use of high-speed motors with comparatively low-speed compressors, and this was less expensive than compressors with motors on the main shaft. The loss in efficiency of the rope drive is 2 per cent, while there is a gain in efficiency and power factor with a high-speed motor over a slow-speed motor.

The rope drives for the compressors and hoists at Vulcan and Republic have been very satisfactory. At Republic one transmission rope has been in use over ten years, although its continuous service would be only about half that, as the plant consists of two compressors driven by water wheels which do not always run at the same time on account of lack of water.

The experience of the past few years indicates that it would have been a less expensive and more efficient installation if instead of putting in compressors at the three mines they had all been placed at the more central point at West Vulcan with pipe lines to East Vulcan, 1½ miles, and to Norway, 1 1/3 miles. If that had been done three compressors, of 1,500 3,000, and 4,000 cu. ft. of free air per minute, would have supplied all the requirements and could be run as required at nearly full capacity at all times. The pipe lines would have been less expensive than the additional compressor required in the plan adopted.

The varying demand for air is readily met with steam compressors by varying the speed, but with constant-speed motor-driven compressors some means must be used to reduce the quantity of air compressed and the amount of power required. All of the above-mentioned electrically driven compressors have choking inlet controllers. The controllers on the West Vulcan compressors have oil dash pots which allow the inlet to be partly or entirely closed. On each end of the high-pressure cylinder is a valve that connects the two ends of the cylinder when the pressure in the intercooler drops below atmosphere. This by-passes the air and prevents excessive heating such as would result if air were compressed in one cylinder from a partial vacuum to full receiver pressure. The East Vulcan compressor has a choking inlet controller without the oil dash pot, and instead of by-passing air from one side of the high-pressure piston to the other, it opens each end to the atmosphere when there is a partial vacuum in the intercooler.

TRAMMING.

The output of the Penn mines has averaged for the last few years about 400,000 tons a year, and this comes from several shafts and from several levels in each shaft. There is no ore body of such size or distance from a shaft as to justify the installation of power trams. Considering the quantities, tramming with mules is satisfactory and economical. On good

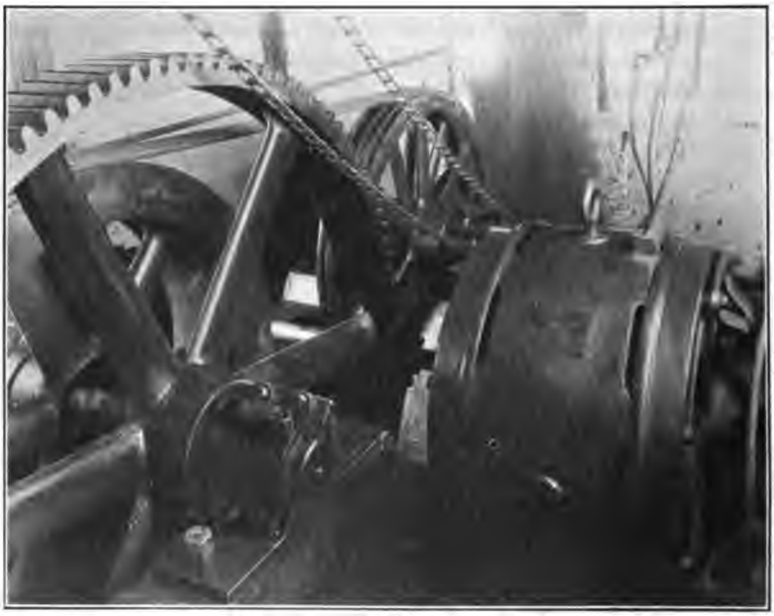

FIGURE 22 TRAMMING PLANT AT THE PENN MINES

roads with even grade, a single mule for some time regularly drew loads of six cars, or 12 tons, of ore a distance of 2,500 ft. The maximum load recorded was 13 cars, or about 26 tons.

The ore hoisted during the winter months is stocked on surface. As there are two, three, or four grades at each shaft, it is necessary in summer to transport the ore from the shaft to the different pockets at the railroad. The movement of stockpile or pocket is done by a car with endless rope which is moved by wheels geared to a motor. This plant is shown in Fig. 22. The tram is driven by a 20-h.p., 220-volt, 720-rev. per minute, wound-rotor, reversible, induction motor.

The drive wheel is made with a rim in halves that can be easily replaced. The drum has four ¾-in. grooves on its outer circumference. About 4 ft. from the center of the drum is a shaft carrying three idler wheels, the center one being keyed to the shaft and the two outer ones being loose on the shaft. This shaft is set at an angle to the horizontal so that the top of one wheel is in line with the first groove of the drum, while the bottom of the same wheel is in line with the second groove on the drum. The rope is led to the first groove on the drum, then around one idler, to second groove, and so on. Having three separate wheels for the idlers reduces the tendency of wear to cause a differential strain on the rope. The drum being split allows of its being replaced quickly when the grooves show a difference in diameter caused by wear. The load of the car is about 6 tons of ore and there are curves in the track of 25-ft. radius. The trestles used for stocking in winter are taken down as the ore is loaded by a shovel during the season of navigation, and are set up again in the fall. This is considered cheaper than to build out tracks on the ore as it is dumped. It also avoids the necessity of any one going out on the trestle during the cold weather except occasionally to oil the rollers. The danger of derailment does not involve life.

For these reasons and because there has been no other need for direct current a trolley system of tramming has not been considered. The quantity of power is comparatively so small that the question of efficiency is secondary to the other elements.

Signal System.

Electric bell signals were originally operated by direct current from primary batteries using one weather-proof wire for each signal (skip, cage, or grade) and a common return. So much trouble was experienced, due principally to electrolysis, that, before the general alternating-current system was put in, a telephone magneto was used by plugging in at different levels and ringing by hand. This prevented any one except the conductor for the cage and the dumpers for the skip, who were furnished with magnetos, from ringing any signals, and stopped all trouble from electrolysis.

When alternating current was available the present system, shown in Fig. 23, was developed. A small transformer takes 110-volt current from the lighting system and reduces it to 30 volts. One side of this low-voltage circuit is connected to the ground, while the other side leads to a relay for each of the bells in the hoist house, skip, and cage, and to one side of a grade bell in the shaft house. The other side of each relay and the grade bell are each connected to one of three No. 4 bare copper wires supported on insulators down the shaft. By grounding any one of these three wires a current will flow through the grade bell or relays in the hoisting house. The bell wire for the cage is near the center of one side of the compartment, so that it is nearly impossible to reach it at any

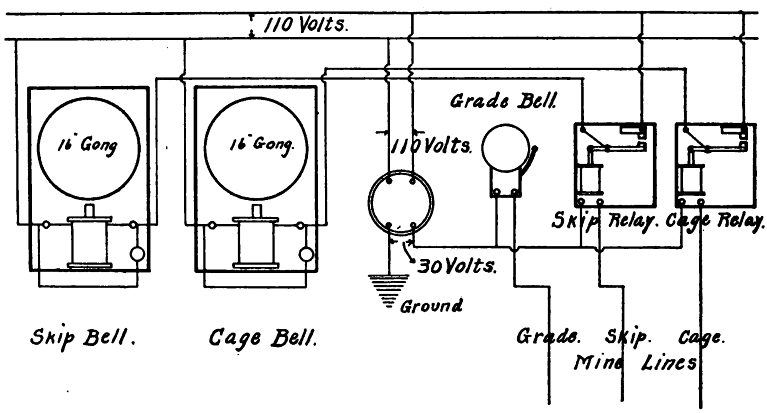

FIGURE 23 SIGNAL SYSTEM

landing place unless one stands on the cage. A short piece of flexible wire, with a bare piece of No. 4 solid wire at the end, is fastened to the iron work of the cage, so that the bell wire for the cage can be grounded from the cage at any point whether at rest or moving. This plan prevents any one from ringing the bell for the cage except from the cage itself. The ringing of the cage bell when the cage is not in sight, although against all rules, is occasionally done and is very likely to have serious consequences. It is the practice at these mines to have each cage handling men, timber, and tools in charge of a conductor, whose place generally is riding on the cage.

The skip and cage bells are 16 in. in diameter and are struck a heavy blow by an alternating-current solenoid using a local 110-volt circuit, this circuit being closed by the relay.

In addition to ringing the bell very loudly an indicator registers the number of bells rung and a lamp at the top center and right hand corner lights. This bell, lamp, and indicator can be seen in Fig. 13.

Power Lines in the Shafts.

All current carried underground is 2,200-volt, three-phase, 60-cycle alternating. At the West Vulcan and East Vulcan No. 4 shafts three separate lines of conduit are carried from the surface sub-station to the pump rooms. Each conduit incloses three separate transmission wires, two of the conduits having No. 00 stranded wires and one having 500,000 circular mils stranded cable. Each wire is insulated with rubber for 7,500 volts, the wall being 30 per cent. Para rubber 5/16 in. thick. The three wires are supported on strain insulators in the shaft house and at stations about every 500 feet. The conduit is sealed at the upper end around the wires to prevent the entrance of moisture and is open at the lower end to allow the moisture of condensation to get out. The first conduits used at the Penn mines were 3-in. pipe lined with fiber. The inside diameter was so small that it was hard to pull the three wires in and after being used some time the moisture caused the fiber to swell so that it was very difficult to get the wires out. The conduits now used are 3-in. Sheraduct for the No. 00 lines and 5 in. for the large lines. The first 2,200-volt underground lines, put down one of the shafts at Republic, were lead-covered cables, three cables in an iron pipe. The alternating current seemed to build up a static charge on the lead covering that punctured the insulation as well as the lead and caused bad short circuits. While wires in a shaft or mine are underground in the miner's use of that term, they are really aerial lines, for they are not imbedded in the ground, under which latter conditions lead-covered wires are properly used.

Conclusion.

Numerous small motors are used for driving hoists and pumps in winzes, timber hoists, portable saws, concrete mixers, and shop tools. At the Penn mines no steam is used except in the saw mill, for heating, and for supplementing the power from the Falls when there is a deficiency. Electricity has been entirely satisfactory from an operating standpoint as well as very efficient. The same men who formerly operated the steam hoists and pumps operate the electric hoists and pumps. The adaptability and reliability of electrical machinery is generally appreciated.

DISCUSSION.

(Including discussion of paper by F. C. Stanford, "The Electrification of the Mines of the Cleveland-Cliffs Iron Company," printed elsewhere in this volume.)

MR. KELLY: There are three principal uses of electricity in mining: for pumping, hoisting and compressing air. The running of a compressor with an electric motor is a simple proposition. One appliance is required with a constant speed motor not necessary with steam compressors—an automatic controller to check the work of compressing when the air pressure reaches the maximum and take it up again when the pressure falls. The motor may be put on the main shaft of the compressor or a motor of higher speed than the compressor may be used to drive it by means of a rope drive or belt. The conditions of each installation will indicate what is best in each case as a question of first cost and efficiency.

In pumping with electricity there are two general methods, one with centrifugal pumps, the other with reciprocating pumps and they each have their limitations and their advantages. For small quantities the centrifugal pump is not adapted and the reciprocating pump is the only one that can properly be used but as the quantity of water increases the efficiency and the advantages of centrifugal pumps improve. The first cost of centrifugal pumps is considerably less in most cases than reciprocating pumps of the same capacity and power. The efficiency of the reciprocating pump, when run to its full capacity, I think I may properly say, is higher than that of the centrifugal pump but it is not always feasible to maintain full capacity. All pumping in mines is with varying quantities. The quantity may vary with the seasons; or with the rain fall. New sources of water may be tapped as openings are extended. Even if the quantity of water that the mine makes is fairly constant, it is frequently necessary to sink a shaft or winze deeper with pumps below the main station pumps delivering to the main pumps intermittently, so that the main pumps have either to run intermittently or with varying quantities. The cenrifugal pump is a pump that can be run with different quantities of water with a comparatively small change in the efficiency, while the efficiency of a reciprocating pump run at full speed and delivering only part of the water would, of course, be in proportion to the quantity delivered. With the Cornish pumping system the usual practice is to have a by-pass and run some of the water back rather than vary the speed or stop and start the pumps. A by-pass may be desirable in starting any pump but its use at other times is a waste of power. The high efficiency of the constant speed motor-driven reciprocating pump is frequently lost by the improper use of the by-pass. To accommodate the variation in the quantity of water with a centrifugal pump, the valve on the suction or discharge (preferably the former) may be opened or closed but with a constant speed reciprocating pump some mechanical arrangement is necessary for changing the length of the stroke, size of plungers, gear ratios—all complicated processes—or the pump must be stopped and started. This last plan necessitates increased sump capacity With centrifugal pumps care has to be taken that they do not lose efficiency by wear. When centrifugal pumps were put in at the Penn mines some seven years ago they had a bad name. There had been great trouble especially with thrust bearings, but our consulting engineers advised us that they were based on correct mechanical principles and that the difficulties in the details could be overcome. This was accomplished and the centrifugal pumps that were put in seven years ago are still running and are considered more reliable than the steam pumps which they displaced. The question as to the use of a reciprocating or a centrifugal type of pump depends, as in fact everything else does, on the conditions to be met. Each has its place and the conditions of each case must determine which should be selected.

Let me say something, too, with regard to the hoisting problem. The method which seems to have had the greatest approval of the electrical engineers is to use a motor generator set. A motor generator set is an arrangement by which on the same shaft is a motor, a fly-wheel and a generator. The motor takes current from the alternating system at high tension and drives the fly-wheel and a direct current generator. Upon the shaft of the hoist is a direct current motor which takes its current from the direct current generator. Its most suitable application is for continuous service where large tonnages have to be raised continuously and the skips are coming up without interruption. But there are a great many mines where this is not the case and as the motor generator set runs constantly, the considerable power used to run the set in the intervals of hoisting is a loss. The operating of the drums by means of a direct current motor is a very smooth and safe plan, but it is accompanied by certain losses of power corresponding to, but possibly exceeding the losses in a mechanical system with clutch and brake. If a motor generator set is not used the motor may be placed on the drum shaft as is frequently done or it may operate a fly-wheel and the drums started by a friction clutch after the other moving parts are up to speed. The hardest part of the work of hoisting is in starting a loaded skip with its rope from rest and bringing it up to speed. If that work is done with a motor without a fly-wheel it takes a tremendous flow of current—a peak load. The system described in the paper "On the Use of Electricity at the Penn and Republic Mines," has the advantage of utilizing a fly-wheel to eliminate the peak at starting and the motor is run only when hoisting is going on. The use of a clutch for starting the drum is the same as with the ordinary geared plant operated by steam that has been in use on Lake Superior for twenty-five or thirty years, and if properly proportioned the clutch requires very little attention. With the use of a counterbalance as described in the paper, the efficiency of the system is all that could be desired and for intermittent hoisting it is particularly well adapted.

Mr. Stanford: I do not believe that I can add very much to what has been said. I agree with the remarks made very heartily. We have made practically all of the applications that have been suggested, excepting, we have not used fly-wheels on induction hoist motors. I will say, however, that we are perfectly safe in using an induction motor directly geared or connected with the hoist when the size of that motor is not greater than ten per cent of the generating capacity of the plant. We have one 500 h.p. motor operating without a fly-wheel with results which are entirely satisfactory, but it seems to be pretty close to the limit which should be applied with the power that we have back of our system. You will note the description of the hoist. We have only one of the fly-wheel sets with direct current motors in service and some fifteen or sixteen of the induction motor driven hoists. You will note in the paper the division as to when the direct current hoist should be applied; that is as far as our experience has gone. As has been said, in selecting a new system for hoisting, if you expect to get perfect results with an Ilgner set, it is absolutely necessary that you shall have a perfect hoisting cycle. If the hoist is designed to carry a five-ton load in a ninety-second cycle, if you carry a five-ton load and increase the cycle to one hundred and eighty seconds, you get no benefit from the fly-wheel set because it will draw back from the line; that is, your fly-wheel will have to come up to full speed at the end of ninety seconds, but if after the close of the ninety-second cycle there is another skip load ready to come up, then you get the full benefit of the fly-wheel.

The only advantage of a fly-wheel in connection with an induction motor hoist is to induce the starting peak. It will actually take more power in k.w. hours than without the fly-wheel.

METHODS OF STOCKING ORE ON THE MARQUETTE RANGE.

BY LUCIEN EATON, ISHPEMING, MICH.*

At all of the producing mines on the Marquette Range, except the open pits, which operate only during the summer months, it is necessary to stock most of the ore produced during the winter, from the middle of November to the middle of April, while navigation on the Great Lakes is closed. The ore that has been stocked during the winter is loaded, usually by steam shovel, during the summer, and shipped to lower lake ports.

For preparing the floors on which the ore is to be stocked two methods are in vogue, and are about equally popular. One is to cover the graded floor with 3-in. plank, usually hemlock, and the other is to use a dressing of lean ore, which when wet down and rolled, cements together and becomes as hard as a macadamized road. The method used depends upon local conditions, the price of plank, and the physical character and value of the ore.

For transferring the ore from the shaft-house to the stock-pile, all the mines use cars, but the manner of handling the cars varies. I have classified the different methods employed as shown in the following table, and have also tabulated the operating mines of the Range according to this classification. This table will be found at the end of the paper. In presenting the different methods I have made no attempt to describe all the details of practice at all the mines, but have selected only typical examples.

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Methods of Stocking Ore.

(A) HAND TRAMMING.

1. Stocking with end-dump cars, using only a short trestle near the shaft-house. Example: Lake Superior Hematite mine.

(B) GRAVITY TRAMMING WITH ROPE PULL-BACK.

1. Stocking with end-dump cars, using only a short trestle near the shaft-house. Example: Salisbury mine.

2. Stocking with side-dump cars, starting from temporary trestles and fanning out on both sides. Examples: (a) Cliffs Shaft mine, (b) Republic mine.

(C) ENDLESS ROPE HAULAGE.

1. Stocking from temporary trestle with gable-bottomed cars. Example: Lake mine.

2. Stocking from permanent trestle with gable-bottomed cars. Example: Negaunee mine, new shaft.

(D) ELECTRIC MOTOR HAULAGE.

1. Stocking with an electric motor and end-dump cars, using only a short trestle near the shaft-house. Example: Mary Charlotte mine.

2. Stocking from temporary trestles with self-propelled, side-dump cars. Example: American mine.

(A) Hand Tramming.

1. *Stocking with end-dump cars, using a short trestle near the shaft-house.* Example: Lake Superior Hematite mine, Ishpeming, Michigan.

At the No. 4 shaft of the Lake Superior Hematite mine the ore is hoisted with a cage in 1½-ton steel end-dump cars and is trammed by hand to the dump on the stockpile. The tracks have about ½ per cent grade in favor of the load, and are laid with 30-lb. rails, with 18-in. gauge. The short trestle is built west from the shaft across a street and is then branched to three piles,—for rock and two grades of ore. A view of the plant is shown in Fig. 1. The ends of the rails on the stock-pile tracks are turned up into horns, and the cars dump against these. From one to three dumps are maintained on each pile, so as to avoid delay in moving tracks.

The crew consists of four men—one lander at the shaft, two trammers, and one man on the dump.

The cycle of operations is about as follows:

	Seconds.
Taking cars off cage	35
Tramming out	60
Tramming back	85
Total	180

Capacity: 20 trips per hour or 30 tons. As the men and supplies have to be handled on the same cage, the maximum capacity is little over 200 tons per shift of eight hours.

The advantages of this system are its low first cost and slight loss of elevation in the pile. As the amount of ore to be hoisted was small, low first cost was essential, and as the stocking trestle, already built, was low, gravity tramming was

FIGURE 1 NO. 4 SHAFT, LAKE SUPERIOR HEMATITE MINE

out of the question. The disadvantages are small capacity and high operating cost.

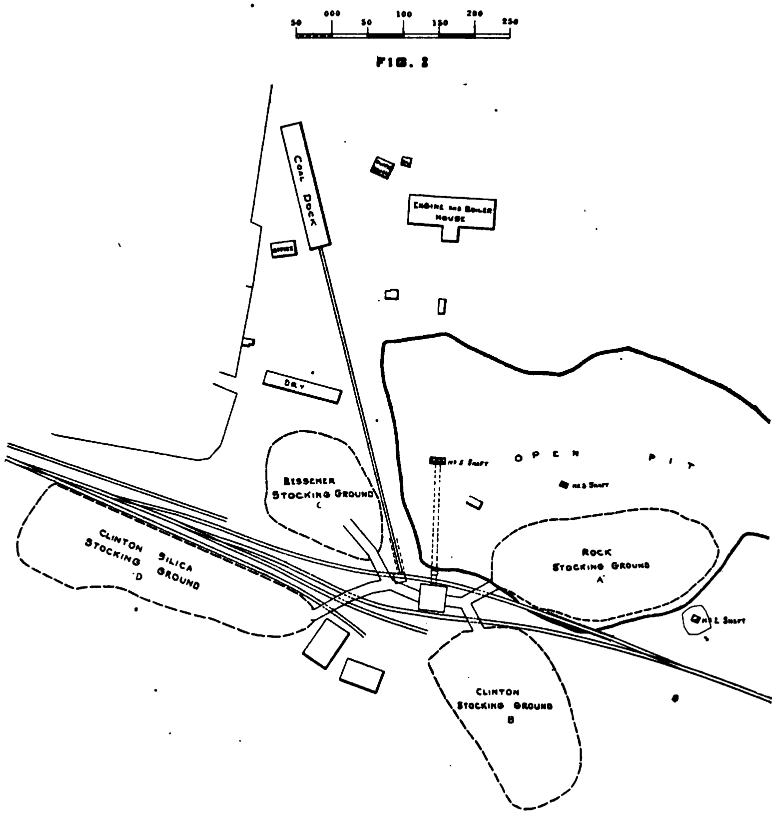
(B) GRAVITY TRAMMING WITH ROPE PULL-BACK.

1. *Stocking with end-dump cars, using only a short trestle near the shaft.* Example: Salisbury mine, Ishpeming, Michigan.

At this plant the rock and three grades of ore are handled with one skip, and the arrangement of the trestles and piles is as shown in Fig. 2. Short trestles are built from the shaft-house to the stockpile grounds, and are extended only far enough to start the piles. The last three bents in each trestle have to be taken down when the pile is shipped. The ore is hoisted in a two-ton skip, and is dumped through a chute into an end-dump iron-body car equipped with brake and rotating table. There are two cars, one serving piles A and B on the east, and the other serving piles C and D on the west. The proper car is spotted under the chute while the skip is being hoisted. The same rope is used for both cars, being connected to either car according to the grade of ore hoisted. The cars run out by gravity and dump over the end of the track or

PLAN OF STOCK-PILE TRESTLES
AT
SALISBURY MINE

FIG. 2



along the side, the track being extended or shifted as the pile is enlarged. They are pulled back by a ½-in. wire rope wound on an 18-in. drum mounted loose on a shaft, to which it is connected by a friction clutch. The shaft is driven directly by a horizontal engine run by compressed air. This engine is at rest except when pulling the car back, and the friction clutch is used as a brake when the car runs out.

The regular crew consists of three men. One man samples the car and operates the drum. Two men ride the car out to the pile, dump it and ride back. These men are responsible for the condition of the track and for extensions.

The track is laid with 30-lb. rails on a 2.75 to 2.5 per cent. grade, with 39-inch gauge. Where the track is straight the rope runs on wooden rollers placed between the rails, and

FIGURE 3 SALISBURY MINE—NO. 5 SHAFT

on the curves it runs on wooden spools covered with 6-in. pipe, placed outside the track.

The cars run out at a speed of from 450 to 500 feet per minute, and are pulled back at a speed of from 500 to 550 feet per minute. The average round trip takes two minutes, making the capacity, counting delays, about 50 tons per hour, or 400 tons per eight-hour shift.

The advantages of this method are low first cost and great flexibility combined with moderate capacity. The disadvantages are the dangers attendant on car riding, delays due to track disturbances from the settling of the piles, reduction of capacity and high operating cost in stormy weather, and loss of height due to the grade of the tracks. Views of the plant and of one of the cars are shown in Fig. 3 and Fig. 4.

2. *Stocking with side-dump cars, starting from temporary trestles and fanning out on both sides.*

EXAMPLE (A): CLIFFS SHAFT MINE, ISHPEMING, MICHIGAN.

The ore at the Cliffs Shaft mine is a hard specular hematite which is separated into two grades according to the size of the pieces before it goes to the stockpile. The run-of-mine ore passes over a grizzly, from which the oversize goes

FIGURE 4 TOP-TRAM CAR, SALISBURY MINE

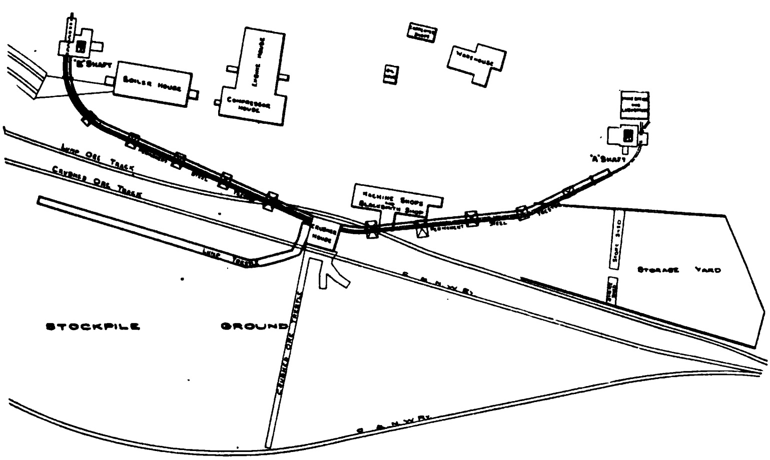
to the lump-ore pocket. The ore passing through the grizzly goes to a revolving screen, from which the oversize passes to a crusher and thence to the same pocket into which the fine ore from the screen falls.

The methods of stocking the two grades of ore, "lump" and "crushed," are essentially the same, but differ in some details, and will be described separately. The plan of the tracks is shown in Fig. 5.

Stocking Crushed Ore—The crushed ore is drawn off from the pocket into a side-dumping car of 56 cu. ft. capacity, which runs out by gravity on the stockpile trestle and is automatically dumped by a dump-stick set between the rails, which trips the door latches. The car is pulled back by a ½-in. rope wound on a small drum in the crusher building. This drum is loose on the shaft and is equipped with a brake and friction clutch. A similar drum is used for pulling back the lump-ore car, and is mounted on the same shaft. A 20-

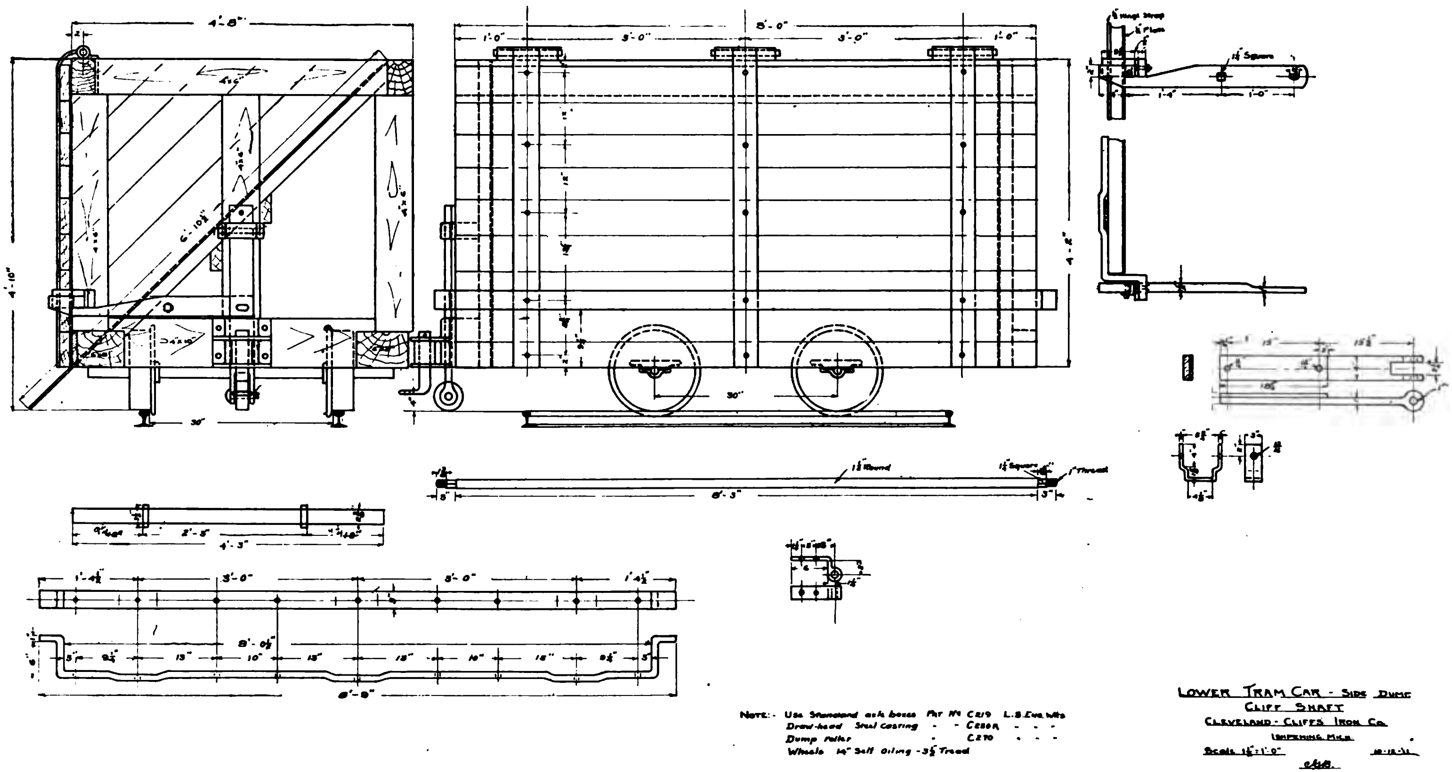
PLAN OF STOCK-PILE TRESTLES
AT
CLIFFS SHAFT MINE

FIG. 5



h.p. motor drives the shaft for both drums. Fig. 6 shows the design of the car, with the exception of the roller-bearings with which the wheels are equipped. The side of the car opposite the door is weighted with about one ton of old rails. Cars run out at a maximum speed of 700 ft. per minute, and are pulled back at 600 ft. per minute.

The car starts on the permanent trestle on a 3 per cent grade, but this is decreased to 2.25 per cent. on the temporary trestle. The track is 30-in. gauge, laid with 25-lb. rails. The



Lower Tram Car - Side Dump
Cliff Shaft
Cleveland - Cliffs Iron Co.
Ishpeming Mich.
Note:- Use Standard axle boxes Pat No C219 L.S. Eve. wks
Draw-head Steel Casting - - C280R - - -
Dump roller - C270 - - -
Wheels 14" Self oiling - 3½ Tread

FIGURE 6

temporary trestle is of the ordinary type for single track, consisting of two-leg bents with corbels and two stringers. It is about 30 ft. high. A floor of 3-in. planks is laid on the stringers, but the rails are not spiked to this floor. Instead they are spiked to ties, which in turn are bolted to the trestle at intervals of about 20 feet. When the trestle is filled on both sides, these bolts are removed, the edge of the pile is smoothed off, the track is thrown over, and stocking is continued. By successive movements of the track the stockpile is widened until it becomes fan-shaped. In this way a pile can be built up containing six to seven times the capacity of the trestle.

When ore is being stocked from the trestle two men are employed at the pocket, one to operate the brake and clutch and the other to fill the car and take samples. Another man is needed when the pile is being "fanned out." The cycle of operations, when the mine is running at full capacity, is about as follows, the dump-stick being set about 300 ft. from the pocket:

	Seconds.
To load	36
To run out and dump	32
To run in	28
Total	96

Capacity: 37 trips or 111 tons per hour. (3-ton cars.)

Stocking Lump Ore—The ore is drawn off from the pocket through a finger chute, operated by an air-lift in the crusher building, into a side-dump car of 56 cu. ft. capacity of the same design as that used for the crushed ore. The car runs down grade by gravity on a single-track trestle, is dumped in the same way as on the crushed-ore pile, and is pulled back by a ½-in. rope wound on a drum in the crusher building. The track is laid on ties on the trestle, just as with the crushed ore, and is moved out on the pile in the same way after the trestle has been filled.

As the lump ore has a comparatively high angle of rest, and as sampling has to be done on the pile, more men are needed on the dump than on the crushed-ore pile. The crew consists of one sampler and two dump-men on the stockpile after the trestle has been filled, and one man at the pocket, who fills the car and operates the haulage drum.

The cycle of operations is about as follows:

	Seconds.
Loading	17
Running out	44
Running in	44
Closing car door	5
Total	110

The capacity is as follows:

Number of trips per hour	32
Tons per hour, 3 tons per trip	96
Tons per shift, 6½ hours tramming	624

FIGURE 7 CLIFFS SHAFT MINE—CRUSHED ORE PILE, SHOWING METHOD OF FANNING OUT FROM TRESTLE

This method has the advantages of comparatively large capacity with great flexibility and low cost of installation and operation. The ratio of storage capacity to trestle cost is high and the dangers of car-riding are eliminated. The disadvantages are the cost of erecting the temporary trestle, the loss of height due to grade in the track, and, with wet or sticky ore, delays due to track disturbances on the pile.

Views of the tops of the piles are shown in Fig. 7 and Fig. 8.

EXAMPLE (B): REPUBLIC MINE, REPUBLIC, MICHIGAN.

The ore at the Republic mine is a hard specular hematite containing little moisture, and is easily handled in the cars. Several different systems of tramming the ore from the shafts to the stockpiles are employed, but only that used at No. 9 shaft will be described.

At No. 9 shaft the ore is hoisted in a 3-ton Kimberly skip and dumped directly into the stockpile car, which is a side-dumping car made entirely of steel. The distinguishing features are the slope of the bottom, which is about 60 de-

FIGURE 8 CLIFFS SHAFT MINE—LUMP ORE PILE, SHOWING METHOD OF FANNING OUT FROM TRESTLE

grees, the arrangement of the trucks, and the tripping-lever. The body is supported on a frame between two swivelled four-wheeled trucks, which enable the car to pass easily around curves of small radius. The tripping-lever is on the side opposite the door, and is adjustable, so that, by using dump-sticks of different heights, three different grades of ore can be stocked from one trestle. Two of these cars are shown in Fig. 9.

The track is laid with 40-lb. rails, with 36-in. gauge, on a 3 per cent. grade. The trestle is single-track, of the ordinary design, and is branched a short distance from the shaft-house, one track leading to the crusher building, one to the rock-dump and one to the stockpile.

The car runs out by gravity and dumps automatically. It is pulled back by a ⅝-in. rope wound on a drum in the shaft-house. This drum is mounted loose on its shaft, is equipped with clutch and brake, and is driven by a rope-drive from the head-sheave of the skip. When the skip is hoisted, the head-sheave drives the drum that pulls the car back. As the depth from which the ore is hoisted is considerable, the car has

FIGURE 9 REPUBLIC MINE STOCKING CARS

ample time to return to the shaft-house before the skip reaches the dump.

One man acts as lander at the shaft, operates the car and throws the switches on the trestle.

The car is of excellent design, but it is expensive to build. Under other conditions, with a different method of operating the pull-back, the capacity of such a system would be large.

(C) ENDLESS ROPE HAULAGE.

1. *Stocking from temporary trestles with gable-bottomed cars.* Example: Lake mine, Ishpeming, Mich.

PLAN OF STOCK-PILE TRESTLES
AT
LAKE MINE

FIG. II.

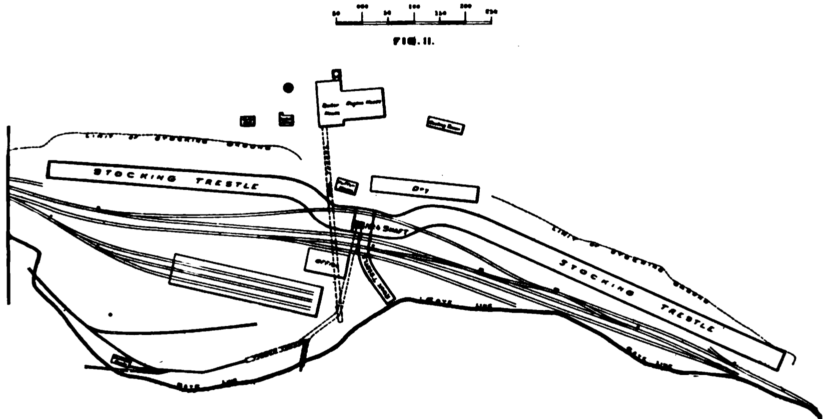


Figure 12 Lake Mine—No. 4 Shaft

Rock and one grade of ore are handled at this plant. The ore is stocked from temporary double-track wooden trestles, built east and west from the shaft. Rock is dumped from a

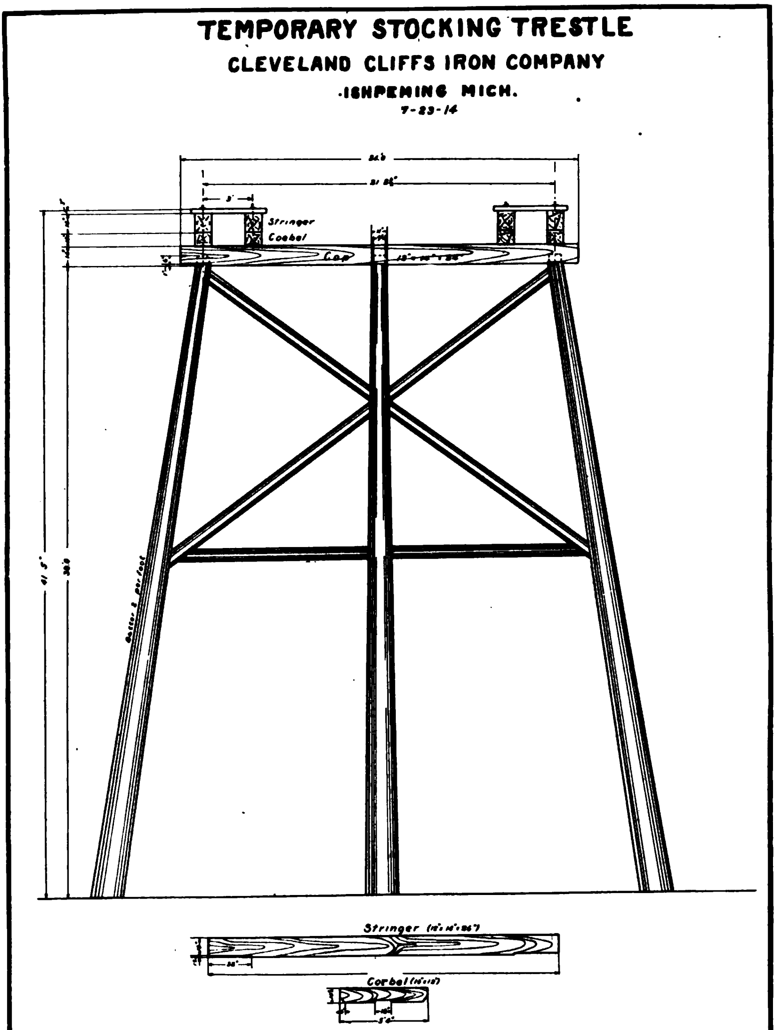
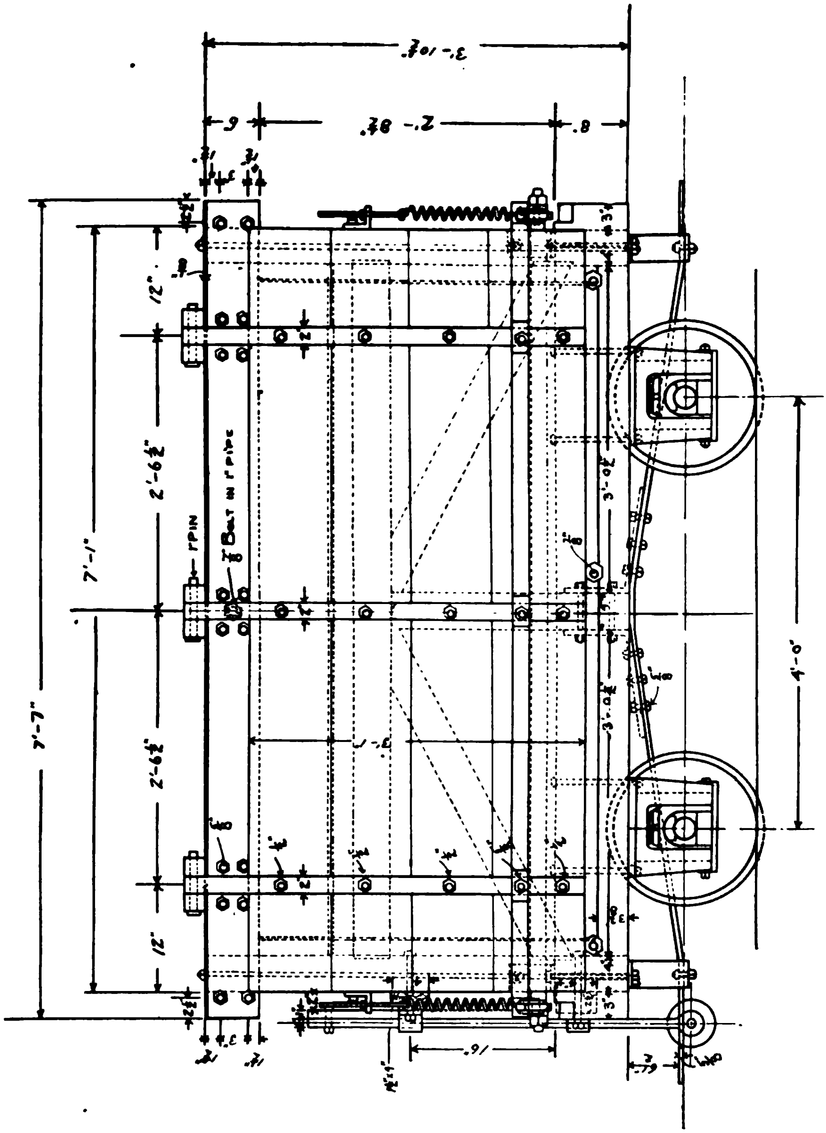


Fig-13

short trestle extending south from the shaft-house. The lay-out of the trestles is shown in Fig. 11 and Fig. 12. There are five bents of permanent trestle on each side of the shaft-



Details	
Oil Box Casting	H-86 - 10x20
Oil Box Guide.	H-122 - 16x20
Oil Box Cellar	H-87 - 10x16
Brasses	H-191 - 8x10
Forgings and Small Casting	H-250 - 20x32
Wheels (16 in Top Tram)	H-244 - 16x20

60 Cu. Ft. Automatic Top Tram Car

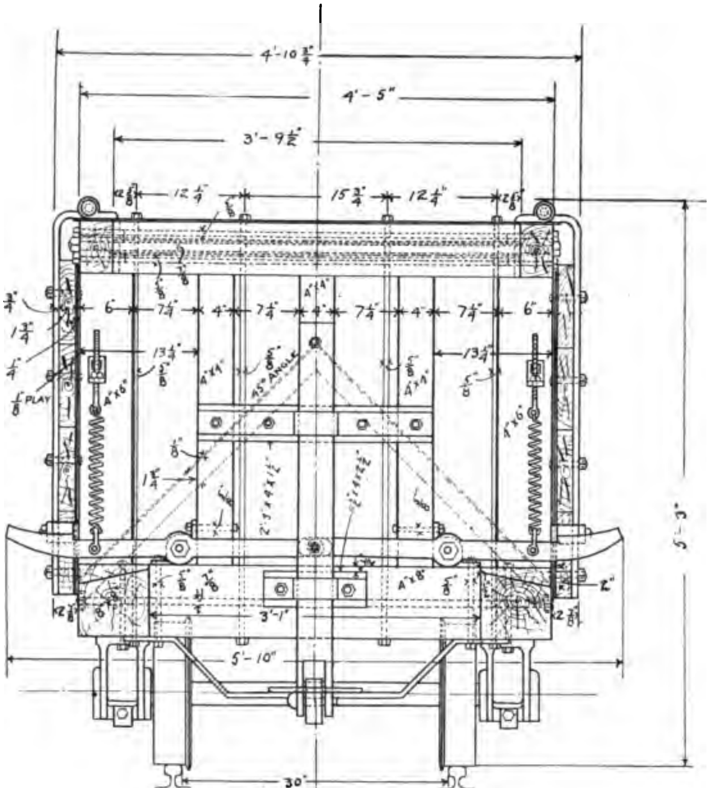
Lake Mine

Cleveland-Cliffs I-Co Ishpeming Mich

Jan 23, 1907 Scale 1½ - 1'

W.H.B.

Figure 10 A



BOLTS

DIA	LENGTH	NO	KIND	PLACE
5/8	4'-6"	4	MACH	THROUGH TOP OF CAR
5/8	3'-11 1/2"	8	"	END OF CAR
5/8	10"	4	"	LATCH ROD BEARING
5/8	5 1/2"	4	"	" " "
5/8	8 1/2"	2	"	LOWER TRIGER GUIDE
5/8	7 1/2"	2	"	UPPER " "
5/8	3 1/2"	2	"	" " "
5/8	5 1/2"	24	"	HINGE
5/8	6 1/2"	2	"	DRAW HEAD
5/8	2"	6	"	" "
5/8	9 1/2"	8	"	PEDESTAL
7/8	4'-8 3/4"	3	"	GIRTH
7/8	4'-6"	1	"	BRACE FOR TOP
5/8	2 3/4"	1	"	TRIGER
1/2	5 1/2"	2	CARRIAGE	CENTER POST STRAPS
1/2	4 1/2"	20	"	
1/2	6 1/2"	36	"	
1/2	8 1/2"	24	"	
1/2	2 1/2"	48	"	
1/2	4	6	"	

FIGURE 10 B 60 CU. FT. AUTOMATIC TOP TRAM CAR—LAKE MINE

house before the temporary trestle begins. The design of the bent used in the temporary trestle is shown in Fig. 13. The trestle is 42 ft. high with bents 26 ft. apart. The tracks are 30-in. gauge, laid without grade with 60-lb. rails, and 3-in. plank is used for ties.

The ore is dumped from the skip to the stockpile cars through a short chute, in which is placed a "butterfly" or swinging door, by which the ore from either skip can be deflected into either car. The cars are of 60 cu. ft. capacity, of the gable-bottomed, automatic-dumping type, as shown in Fig. 10. Both cars are moved by endless, 5/8-in. wire ropes, driven by a 40-h.p. Corliss engine located in a small house on the ground level. Each rope makes four turns about two 4-ft. drums mounted loose on parallel shafts 10 ft. apart. These shafts are driven in opposite directions by a crossed belt, and the car is pulled in or out by throwing in the friction clutch on one drum or the other. The maximum rope speed is 1,000 ft. per minute.

From the car the haulage rope runs out along the track over wooden rollers to a tightener at the end of the trestle; it is deflected at the turns by 16-in. cast-iron sheaves. This tightener, the design of which is shown in Fig. 14, consists of a cast-iron sheave (A) mounted on a small carriage (B) on the track, and holds the rope in tension by means of a compression spring (C) enclosed in a piece of 6-in. pipe. Adjustments are made by a long screw (D) behind the spring. The return rope is carried on rollers on the caps of the bents between the two tracks, over a turn-sheave, and down to the haulage engine. Ore is stocked on one side of the shaft until that trestle is filled, and the ropes are then moved to the other side.

As it is impossible for the engineer operating the haulage engine to see the stockpile cars, special signals for spotting them are necessary. When a car is spotted in the right position under the chute, an electric contact is made between a steel spring that projects above the side of the car under the lip of the chute and a metal band on the under side of the lip of the chute. This steel spring is connected by a wire with the axle of the car, so that when it comes in contact with the band on the lips of the chute, the circuit is grounded, and a pair of red lamps are lighted in front of the haulage engine. There is one of these signals for each car. As a precaution against running the car off the end of the trestle the last 100

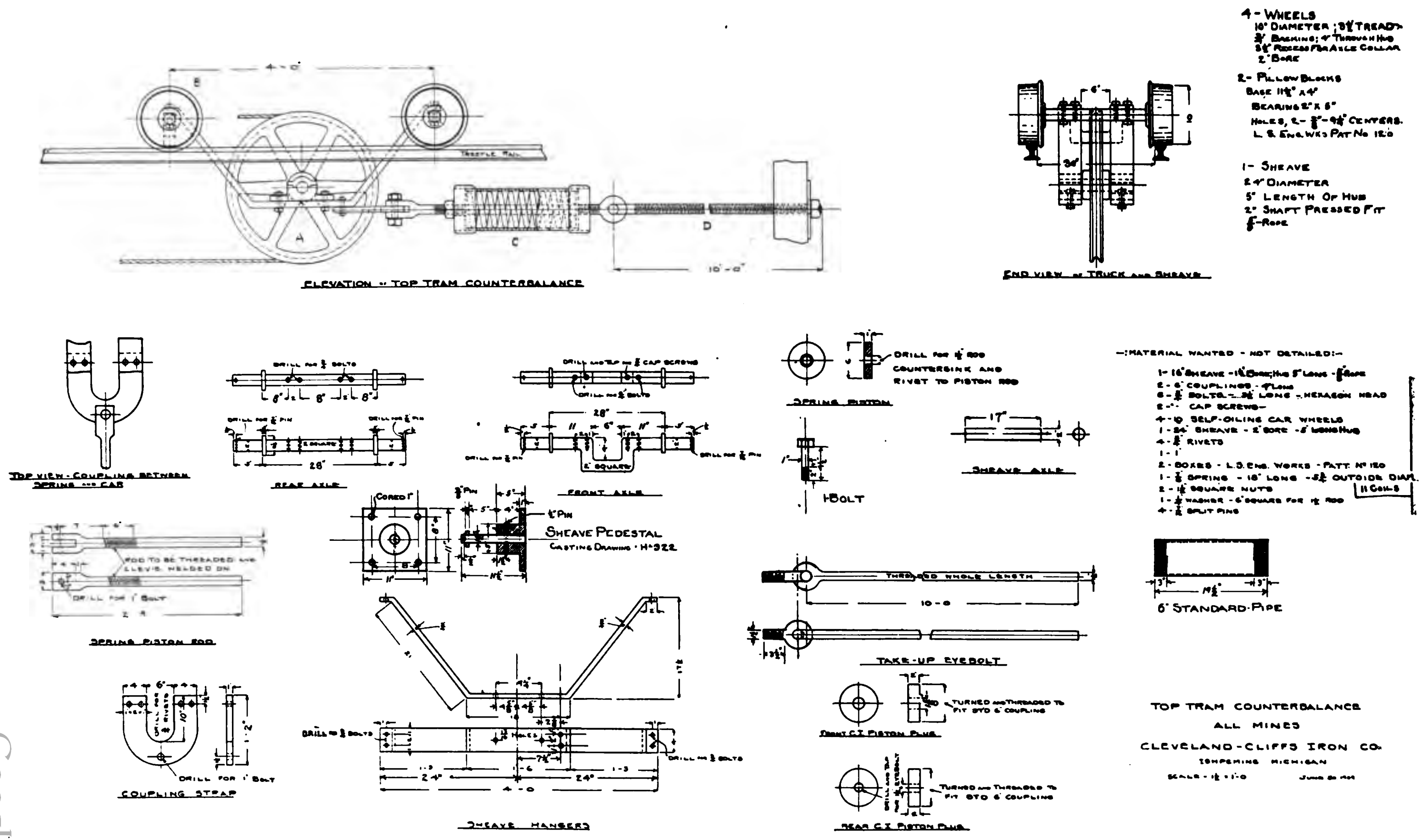

ELEVATION OF TOP TRAM COUNTERBALANCE
END VIEW OF TRUCK AND SHEAVE
4 - WHEELS
10" DIAMETER; 3¼" TREAD
2 - PILLOW BLOCKS
1 - SHEAVE
24" DIAMETER
5" LENGTH OF HUB
2" SHAFT PRESSED FIT
TOP VIEW - COUPLING BETWEEN SPRING AND CAR
REAR AXLE
FRONT AXLE
SPRING PISTON
DRILL FOR 1¼" ROD COUNTERSINK AND RIVET TO PISTON ROD
SHEAVE AXLE
1-BOLT
MATERIAL WANTED - NOT DETAILED:-
SHEAVE PEDESTAL
CASTING DRAWING - No 322
SPRING PISTON ROD
THREADED WHOLE LENGTH
TAKE-UP EYEBOLT
6" STANDARD PIPE
COUPLING STRAP
DRILL FOR 1" BOLT
SHEAVE HANGERS
FRONT C.I. PISTON PLUG
REAR C.I. PISTON PLUG
TURNED AND THREADED TO FIT STD 6" COUPLING
TOP TRAM COUNTERBALANCE
ALL MINES
CLEVELAND-CLIFFS IRON CO.
ISHPEMING MICHIGAN

FIGURE 14

ft. of rails are insulated from each other and from the rest of the track, and when the car reaches that part of the track, a cluster of lamps are lit over the haulage engine. In addition, marks are made on the rope to indicate the position of the car when it is at the dump-stick and at the shaft. These marks are made by tying cotton wicking around the rope for a length of five or six inches, using a single knot at every half turn. The engineer receives his signals for moving the cars by electric bell from the landing floor.

Rock is trammed by gravity from the south side of the shaft-house in an end-dump car, which is pulled back by a small steam engine located on the landing floor. When not in use this car is kept out of the way under the south skip-chute, but when rock is to be trammed a set of temporary rails are swung across the ore-track, and the rock car is pushed out far enough to receive its load from the skip.

The operation of the stocking plant requires five men on each shift, one haulage-engineer and four top-landers. One top-lander operates the "butterfly" and the rock-car engine, rings bell signals, and keeps the tally of skips and cars; one oils spools and rollers, and keeps the tracks and skip-dumps clean and free from ice; and the other two operate the rock car, brace the doors of the ore cars spotted at the chutes, sample the cars, and keep the landing floor clean.

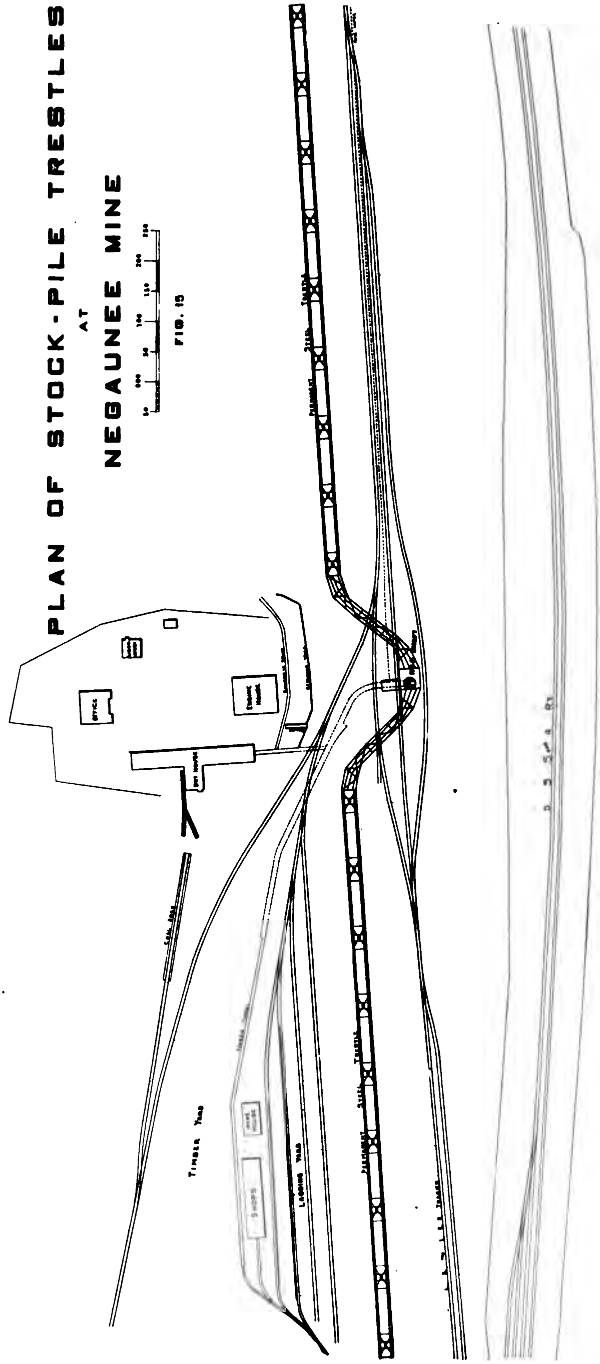
The cycle of operations is about as follows:

	Seconds.
To load	10
To run out and dump	55
To run in	55
Total	120

The capacity per car is 30 trips or 90 tons per hour. The capacity for both cars is 180 tons per hour.

When the dump is at considerable distance from the shaft the cars are run in trains of two, the two cars in each tram being separated about 25 feet. In this case the cycle of operations is about as follows:

	Seconds.
Loading first car	10
Spotting second car	10
Loading second car	10
Running out	70
Running in	70
Total	170


PLAN OF STOCK-PILE TRESTLES
AT
NEGAUNEE MINE
FIG. 15
PERMANENT STEEL TRESTLE
PERMANENT STEEL TRESTLE
TIMBER YARD
LAGGING YARD
SHOPS
OFFICE
DRY HOUSE

The capacity per train is 21 trips or 126 tons per hour. The capacity for all four cars is 252 tons per hour.

This figure is about right when the dump-stick is set from 900 to 1000 ft. from the shaft. A capacity of 150 tons per hour has been maintained when ore is stocked 1600 ft. from the shaft.

The advantages of this system are large capacity combined with low operating cost and reliability under all sorts of weather conditions and with all kinds of ore. The dangers of car riding are also eliminated. The disadvantages are high cost of installation and maintenance and lack of flexibility.

It is possible to fan out from the trestles with a side-dump

FIGURE 16 NEGAUNEE MINE TRESTLE

car, using the endless-rope haulage system, and this method is sometimes used at the Lake mine and at others where similar plants are installed, but on account of its higher cost of operation and lower capacity, it is resorted to only in emergencies.

2. *Stocking from permanent trestle with gable-bottomed cars.* Example: Negaunee mine, Negaunee, Mich.

At this plant rock and two grades of ore are handled on one trestle. A permanent double-track steel trestle extends approximately 1500 ft. east and west from the shaft house, and a wooden trestle is built at the west end of the steel trestle. Ore is stocked from the steel trestle and rock from the wooden trestle. The steel trestls is 42 ft. high, and is supported on reinforced concrete pillars, the length of the spans being 114 feet. A detailed description of this trestle is given in a paper by Mr. S. R. Elliott, presented at this meeting of the Institute. A view of the trestle is shown in Fig. 16. The tracks are 30-in. gauge, and are laid with 40-lb. rails.

The ore is dumped directly from the skips into two gable-bottomed cars of 75 cu. ft. capacity; these can be hauled either way from the shaft-house. Each car is moved by an endless ⅝-in. wire rope 5500 ft. long driven by a 50-h.p. induction motor operating a drum and idler. The haulage motors are on the ground level in a building by themselves, but the controllers are in a concrete shanty on the landing floor. From here the operator can watch both of the cars and spot them directly. The ropes are kept in tension by the same type of tightener as described for the Lake mine, but the slack is not taken up by a screw as at the latter mine, but by a counterweight suspended from the end of the trestle. The car doors are opened by a tripping-lever, which is raised by a dump-stick set between the rails. The maximum car-speed obtained is 1200 ft. per minute.

The average time is about as follows:

	Seconds.
To spot and load	10
To run out and dump	55
To run in	55
Total	120

Capacity: 30 trips per hour with each car, or about 240 tons per hour in all.

The advantages of this system are large capacity and reliability under all sorts of weather conditions and with all kinds of ore, combined with low operating and maintenance costs. Also the dangers of car riding are eliminated. The disadvantages are high first cost, lack of flexibility, and high cost for power.

(D) Electric Motor Haulage.

1. *Stocking with an electric motor and end-dump cars, using only a short trestle near the shaft-house.* Example: Mary Charlotte mine, Negaunee, Michigan.

At the Mary Charlotte mine three grades of ore are stocked in separate piles on the west side of the shaft, and rock is dumped on the east side. A short trestle extends from the shaft-house to the first point of dumping in each case, and from there on the track is laid on the top of the pile itself as it advances. The track is of 36-in. gauge, laid with 60-lb. rails, and is kept level. The plan of the tracks is shown in Fig. 17.

The ore is hoisted in 4¼-ton skips, and is dumped directly into an end-dump steel car equipped with a ball-bearing turntable. This car is pushed out to the dump by a 6-ton electric

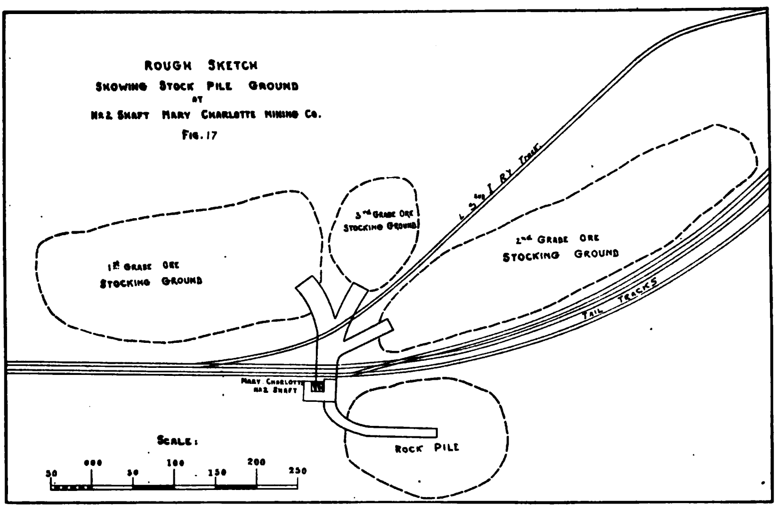


FIG. 17

locomotive. One car is used for all three grades of ore and another car for rock. The same motor serves both cars. The ore car and motor are shown in Fig. 18. The trolley-wire is carried on overhead crosspieces supported on small poles erected at the side of the trestle. It is extended only as far as the dump.

The crew on each shift consists of a motorman and two car-dumpers, who all ride on the motor, and a lander who stays at the shaft, rings the bell, regulates the distribution of the ore, and keeps the landing floor clean. On day shift two or more men in addition are needed on the dump to make extensions and keep the tracks in order.

The cycle of operations is about as follows when ore is dumped 250 ft. from the shaft:

	Seconds.
Spotting and loading	15
Running out	40
Dumping	25
Running in	40
Total	120

Capacity: 30 trips per hour, or 128 tons. As the distance from the shaft increases, the capacity is reduced. An average of 600 tons a shift of eight hours is considered good work.

The advantages of this system are its flexibility, the low

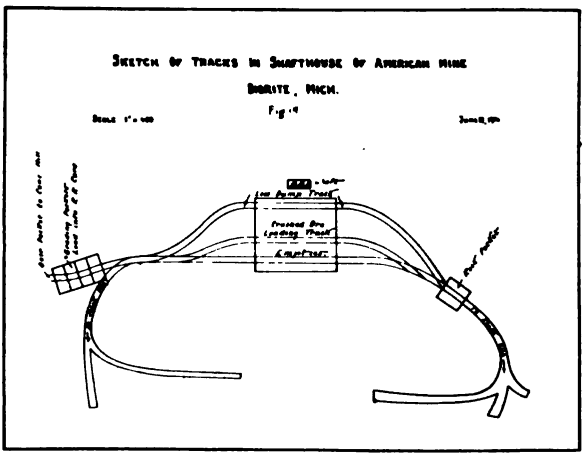
FIGURE 18 TOP TRAM CAR AND MOTOR—MARY CHARLOTTE MINE

first cost of the trestles and equipment, low maintenance, and comparative freedom from delay on account of bad weather. The disadvantages are danger to employes, especially to the three men who ride, and delays from track disturbances, due to settling of the pile either from the frost melting out of the upper parts or from excessive moisture in the ore.

2. *Stocking from temporary trestle with self-propelled side-dump cars.* Example: American mine, Diorite, Michigan.

At the American mine the ore is hoisted through an inclined shaft by two skips; these dump directly into a No. 8 gyratory crusher. The ore, as it is discharged from the crusher, falls through a small chute into a side dumping self-propelled car or "larry" of 80 cu. ft. capacity, by which it is transferred to the railroad pockets, to the stockpile, or to the concentrator. Rock, concentrating ore, and four grades of high-grade ore are handled.

In stocking ore temporary single-track trestles are used, a plan of which is shown in Fig. 19. When these are filled the track can be moved over on the pile, as is done at the Cliffs Shaft mine. The tracks are level, laid with 60-lb. rails, and have 40-in. gauge. There are three tracks across the shaft-house on the landing floor, two for loading at the chutes and one for a turn-out.



The car or larry consists of a wooden body with a sloping floor and with a hinged door on the side, mounted on a steel frame. The door is opened and closed by a simple toggle and lever, operated by the man who rides the car. The steel frame carrying the car body is supported at one end by a small four-wheeled truck, which is free to turn on a swivel, and at the other end by a single pair of 20-in. wheels, to which the driving motor is geared. The motor is a 6-h.p. 250-volt direct-current crane motor. Each car is equipped with a controller and foot-brake. The trolley-wire is supported on horizontal poles at intervals of from 15 to 20 feet. A view of this car is shown in Fig. 20.

FIGURE 20 AMERICAN MINE STOCKING CAR

FIGURE 21 AMERICAN MINE SHAFT

The crew consists of one lander and two car-riders on each shift. Ordinarily only two cars are needed, but when hoisting is brisk, an additional car is used, one car being left under the crusher chute while the other two are making their trips. Two car-riders operating three cars in this way have an average working capacity of 100 tons an hour, and a maximum of 160 tons an hour.

The cars travel at a speed of from six to eight miles an hour.

The advantages of this system of stocking ore are extreme flexibility, positive action, a small operating crew, relatively low power-cost, and maximum trestle capacity. Its disadvantages are the dangers attendant on car-riding on trestles, and the cost of maintenance of trestles and cars.

Tabulation of Stocking Methods Employed at Various Mines.

A—HAND TRAMMING.

1. Stocking with end-dump cars, using only a short trestle near the shaft house.

Lake Superior Hematite mine, Ishpeming, Mich.
Stegmiller mine, Princeton, Mich.

B—GRAVITY TRAMMING WITH ROPE PULL-BACK.

1. Stocking with end-dump cars, using only a short trestle near the shaft house.

Salisbury mine, Ishpeming, Mich.
Austin mine, Princeton, Mich.
Chase mine, Ishpeming, Mich.
Section 16 mine, Ishpeming, Mich.
Lake Superior Hard Ore, Ishpeming, Mich.
Queen mine, Negaunee, Mich.
Prince of Wales mine, Negaunee, Mich.
Rolling Mill mine, Negaunee, Mich.
Cambria mine, Negaunee, Mich.

2. Stocking with side-dump cars, starting from temporary trestles and fanning out.

Cliffs Shaft mine, Ishpeming, Mich.
Republic mine, Republic, Mich.

C—ENDLESS ROPE HAULAGE.

1. Stocking from temporary trestle with gable-bottomed cars.

Morris mine, Ishpeming, Mich.
Lloyd mine, Ishpeming, Mich.

Lake mine, Ishpeming, Mich.
Maas mine, Negaunee, Mich.
Gwinn mine, Gwinn, Mich.
Mackinaw mine, Gwinn, Mich.
Princeton mine, Princeton, Mich.
Stephenson mine, Princeton, Mich.

2. Stocking from permanent trestle with gable-bottomed cars.

Negaunee mine, Negaunee, Mich.

D—ELECTRIC MOTOR HAULAGE.

1. Stocking with electric-motor and end-dump cars, using only a short trestle near the shaft house.

Mary Charlotte mine, Negaunee, Mich.
Volunteer mine, Palmer, Mich.
Lake Angeline mine, Ishpeming, Mich.

2. Stocking from temporary trestle with self-propelled, side-dump cars.

American mine, Diorite, Mich.

GENERAL OUTLINE OF MINING METHODS USED IN THE COPPER QUEEN MINE, BISBEE, ARIZ.

BY JOSEPH PARK HODGSON, BISBEE, ARIZONA.*

The Copper Queen, which might be called a group of mines, is the principal mining operation of the Copper Queen Consolidated Mining Company. Mining operations were commenced in 1880. The famous Queen orebody, which extended to the surface, was quarried from a large open cut in the outcrop. The orebody was followed down to the 300-ft. level with the Queen incline and stoped by the square-set method. This, I believe, marks the introduction of square-setting into the Bisbee district. It is still the system of stoping most commonly practiced.

Orebodies—The orebodies in the Copper Queen mine occur in the limestones, and most of the ore has been mined from the Abrigo, Martin and Escabrosa limestones. While the orebodies outcrop in the extreme western end of the mine, the general dip is to the east and south, at an angle of about 20 degrees. This dip is not by any means regular, however; in fact, it is very irregular locally. The ore varies remarkably in character, some of it being very soft and requiring a large amount of timber, and other portions consisting of extremely hard sulphides. In general the orebodies are remarkable for their continuity, but very irregular as to shape and size. As the mine has been in operation so many years, and over such a large area, the overburden is constantly shrinking. The constant movement resulting, shown by large cracks and interstices in the surface rocks, contributes largely to the very high deadwork or maintenance cost of the mine. For the year 1913 the one item of repairs and deadwork amounted to almost $400,000.

*Mine Superintendent Copper Queen Consolidated Mining Co.

C. SURFACE ABOVE DIVIDEND ORE BODY, CZAR MINE. COPPER QUEEN C. M. CO. FILLING ON THE RIGHT

Haulage and Hoisting—The underground openings have been extended in the neighborhood of two hundred miles. The ore is hoisted at a centrally located shaft, the Sacramento, to which it is conveyed from different parts of the mine by electric haulage. There were slightly over nine miles of electric tramway in operation in 1913. The hoisting levels at the Sacramento shaft are 200 ft. apart, commencing at the 400-ft. level and continuing down to the 1600-ft. level, the average hoisting distance being 1,000 feet. Kimberly skips are used, and are loaded from pockets. As high as four hundred skips have been hoisted through this shaft in a 7½-hour shift.

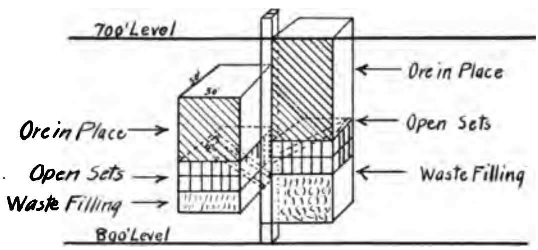
Intermediate tramming to haulage chutes is done, in general, by mules and by hand. Waste material is used for filling the square-set and cut-and-fill stopes. Any surplus waste rock is sent to the surface at the subsidiary shafts, of which there are seven in operation. These shafts are also used for hoisting and lowering men, timber and supplies.

Lighting—All main haulage-ways, powder houses, etc., are lighted by electricity. The workmen have been using candles, but carbide lamps are being substituted for them. It is thought that there is less danger of fire with the carbide lamps, and it has also been demonstrated that carbide is more economical. They also give a better light, which enables the workmen to see better, a distinct advantage because of the large amount of ore that is sorted underground.

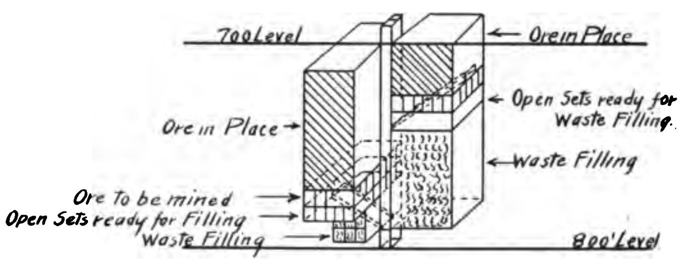
Compressed Air—All hoists, with the exception of the Sacramento, are operated by compressed air generated at the central power plant by compressors having a total capacity of 21,000 cubic feet of free air per minute. Electric power for underground and surface lights and for haulage is supplied by three Curtis turbo-generators, which are connected with seven 407-h.p. water-tube boilers.

Square-Setting—Up to about a year ago, square-setting was the only method practiced in this property. The system, as a whole, has been very successful. It is quite elastic; and stringers can be followed from any point in the stope and prospecting is efficient. Perhaps the greatest objection to it is that in very soft ground the stopes may close in from the excessive weight. The timber cost is also very high, and as a whole, perhaps the system is not as economical as some others. Nevertheless a very large portion of the mine will always be worked upon this plan, by reason of the very unequal and changing character of the ground.

The general custom in the square-setting system practiced here is to block the ore out in sections, numbering the sections consecutively, and mine, if possible, four sections around one central raise. This can quite often be done, but frequently the ground is so heavy, and so much weight is thrown upon the timbers, that it is impossible to take out more than two or three sections to a raise. These sections are laid out according to the local character of the ground, and are from two to



Square Setting
Fig 1



Square Setting
Fig 2

FIGURE 1 AND 2 ILLUSTRATE DIFFERENT STAGES OF EXTRACTING THE ORE BY MEANS OF SECTIONS WHICH WAS EXPLAINED UNDER THE SQUARE SET SYSTEM. THE CHUTES ARE SO ARRANGED AS TO REQUIRE THE LEAST AMOUNT OF MUCKING.

four sets in width, and from six to ten in length. The sections must be laid out with great care, because if they are too large or too wide, the stope may cave in. As the stoping progresses from the sill upward, the raise is usually extended to the next level. This gives proper ventilation to the stope, and besides, the raise is almost necessary for the lowering of timbers and the dumping of filling; it has been found necessary to carry the filling to within about two floors of the back of the stope and immediately below where men are working.

In many of the stopes, particularly in the oxide ores, a good deal of the ore is sorted, as it has been demonstrated that it is cheaper to sort out the waste in the stope. In many cases this increases the mining cost quite materially, yet the Company has no doubts of its being good business to leave the waste in the gob rather than to put it into chutes, tram and hoist it, and pay transportation and smelting charges upon it. So that nothing will be mined but what shows a margin of profit, a system of minima, based upon the selling price of copper, has been put into effect.

Cut and Fill—Within the last two years, the management has been making some experiments in other mining methods, and in certain portions of the mine, notably in the Holbrook, Spray and Gardner divisions, some cut-and-fill stopes have been opened. This system of mining is of course applicable only in hard ground, and these stopes are exclusively in sulphide ores. The experiments have, to date, proved quite successful, and have materially decreased the mining cost from that of the square-set method, and it is believed that this system should be used wherever the conditions are suitable. The method in use is somewhat as follows:

The orebody is prospected as far as possible in advance, and the side and vertical dimensions of the ore determined. Drifts are driven where possible under the bottom of the ore and raises put through the ore to the level above to permit the dumping of filling. Chambers are then cut out and drifts formed either by cribs or by sets of timber. The back is blasted down, the raises are cribbed up at convenient points, and filling is dumped in for the men to stand upon, so that they will at all times be working close to the back. Wherever possible the stope is worked on an angle of about 45 degrees, so that the broken ore may slide down to the chutes upon a plank bed laid upon the filling. This plan materially reduces the cost of getting the ore into chutes, and is advantageous wherever it can be adopted. Prospecting can be done from any elevation, as the stope is worked up to that point and the filling is easily and cheaply disposed of. Wherever it is possible to work a stope upon an angle of 45 degrees, very little timber is needed, as the slope of the ground helps to support the stope. Wherever a stope cannot be worked upon the slope and where the backs are carried more or less horizontal, they must often be blocked up temporarily or supported by cribbing to make the stope safe while the ore is being extracted.

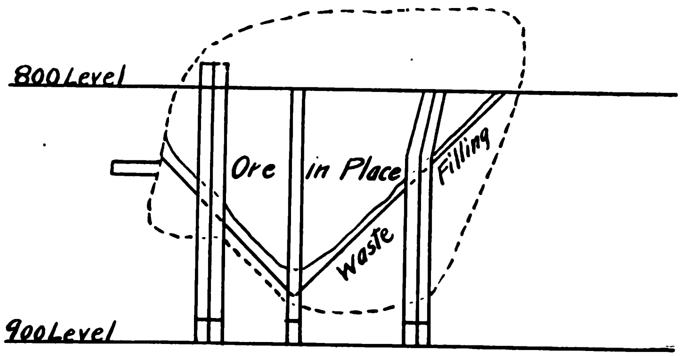


Fig. 3. Cut and Fill

Figure 3. Starting at the Top of the Slope, Water Holes Are Drilled and a Section of Ground About 8 ft. Thick and 20 ft. Wide is Blasted Down. The Work is Done Underhand Wherever it is Possible in Order to Keep the Back Solid.

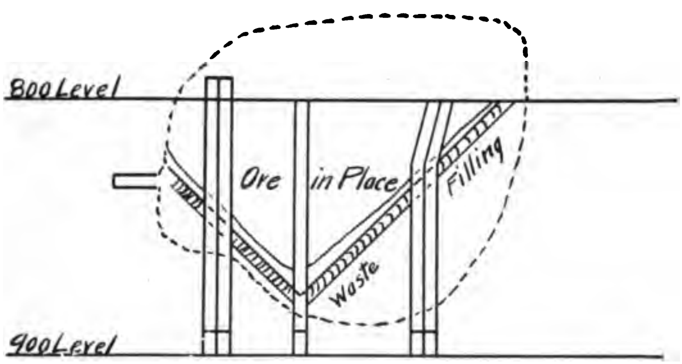


Fig. 4. Cut and Fill.

Figure 4, Shows that the Ore Has Been Removed, Waste Filling Has Been Run in and is Again in the Condition as Shown in Figure 3.

This system is also quite elastic, inasmuch as small blocks can be worked out wherever it is deemed necessary in case the back is heavy and will not admit of being opened up in a fairly large chamber. One absolute necessity in working this system is that the men be watched closely and taught to bar down the backs and take down all loose or unsafe ground before they set up their drills. Perhaps the system is at a disadvantage where the ore is intersected by stringers or bunches of waste; however, if care is taken, this waste can always be blasted down or put in the gob and the ore mined clean. The cut-and-fill method thus far has worked quite successfully in the Copper Queen mines, and the writer knows of many mines in Michigan and other places that have been worked successfully by similar systems.

Shrinkage—Up to the present time, only one place has been found in the Copper Queen mine where in our judgment a shrinkage stope could be developed. This stope is on the 1100-ft. level of the Lowell mine, upon an orebody approximately 100 ft. long and 50 ft. wide. To use the shrinkage system successfully, the character of the surrounding walls must first be ascertained; it must be demonstrated beyond a doubt that they are strong enough to permit the removal of the ore after it has been mined to the top of the orebody or to the level above. Such work is under way at present in the Lowell mine, and promises to show a substantial reduction in cost as compared to square-setting in the same character of ground. Practically no timber is needed, and as the ore is kept close to the back, the workmen are at all times close to the working face. As with the cut-and-fill system, care must always be taken that the workmen bar down and make safe the backs before commencing drilling operations. One disadvantage of the shrinkage system is that bars of waste occurring in the orebody must necessarily be broken down and thus may become mixed with the ore.

Top-Slicing—Another system that has also been receiving attention in these properties is that of the top slice. The top-slicing system probably originated in the iron ore mines of the northern part of England, and, I believe, was first introduced in this country in the iron mines in northern Michigan. This system consists of first driving in the main level drifts, crosscutting and finding the extent of the orebody, putting up raises through the orebody to the top of the ore, and commencing operations at the extreme top of the orebody. It must, of course, be demonstrated to the satisfaction of the management that there is no possibility of other orebodies lying over the country that is to be mined, as the system,

D. Another View of Surface Above Dividend Ore Body, Czar Mine. Filling on the Left. Copper Queen C. M. Co.

A. Concrete is Mixed Immediately Above Dividend Ore Body for Concrete Raises in Foot-Wall of Ore Body, Czar Mine, Copper Queen C. M. Co.

when properly used, does not necessitate filling. The operations consist simply of driving lateral drifts and taking out the ore in small blocks,—making sure to clean the top of the orebody,—and placing either plank or split lagging upon the sill of every individual slice as the operations are continued downward, thereby forming a mat upon which the overburden and debris will rest. It is usually found in the preliminary

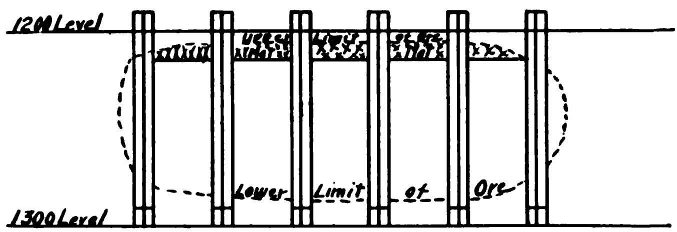


Fig. 5 Top Slicing

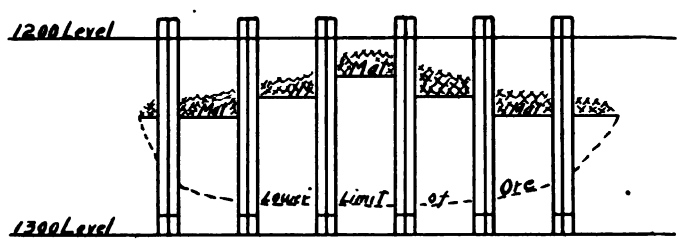


Fig. 6 Top Slicing

FIGURE 5, SHOWS A TOP-SLICE STARTED AND MAT FORMED. FIGURE 6 SHOWS EXTREMITIES OF ORE BODY BEING TAKEN OUT IN ADVANCE OF CENTRAL PORTION. THIS IS DONE WHERE A MAIN EXTRACTION TUNNEL IS IMMEDIATELY BELOW THE SLICE IN ORDER TO OBVIATE REPAIR COSTS IN MAIN LEVELS.

operations of a top slice that the overburden is heaviest while the first three or four slices are being extracted. After this, the mat, old timber and overburden become intermixed, and in a measure self-sustaining.

This system can be used to advantage in very soft or wet ground; it is the writer's opinion that in such cases it will succeed and return a profit where square-setting and other methods fail. Top-slicing has been commenced in what is known as the Dividend slice of the Czar mine. This orebody contains perhaps from 750,000 to 1,000,000 tons of very soft, wet, aluminous ore. Square-setting wherever tried in this

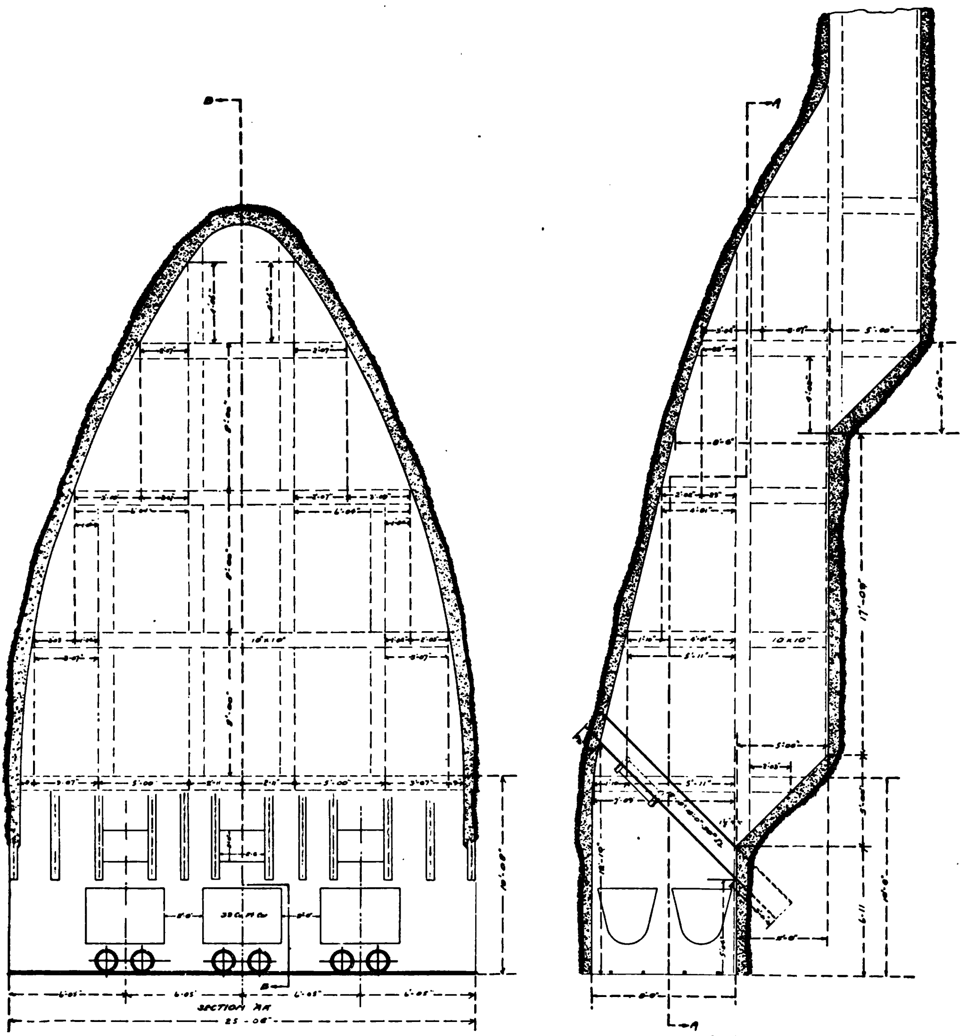
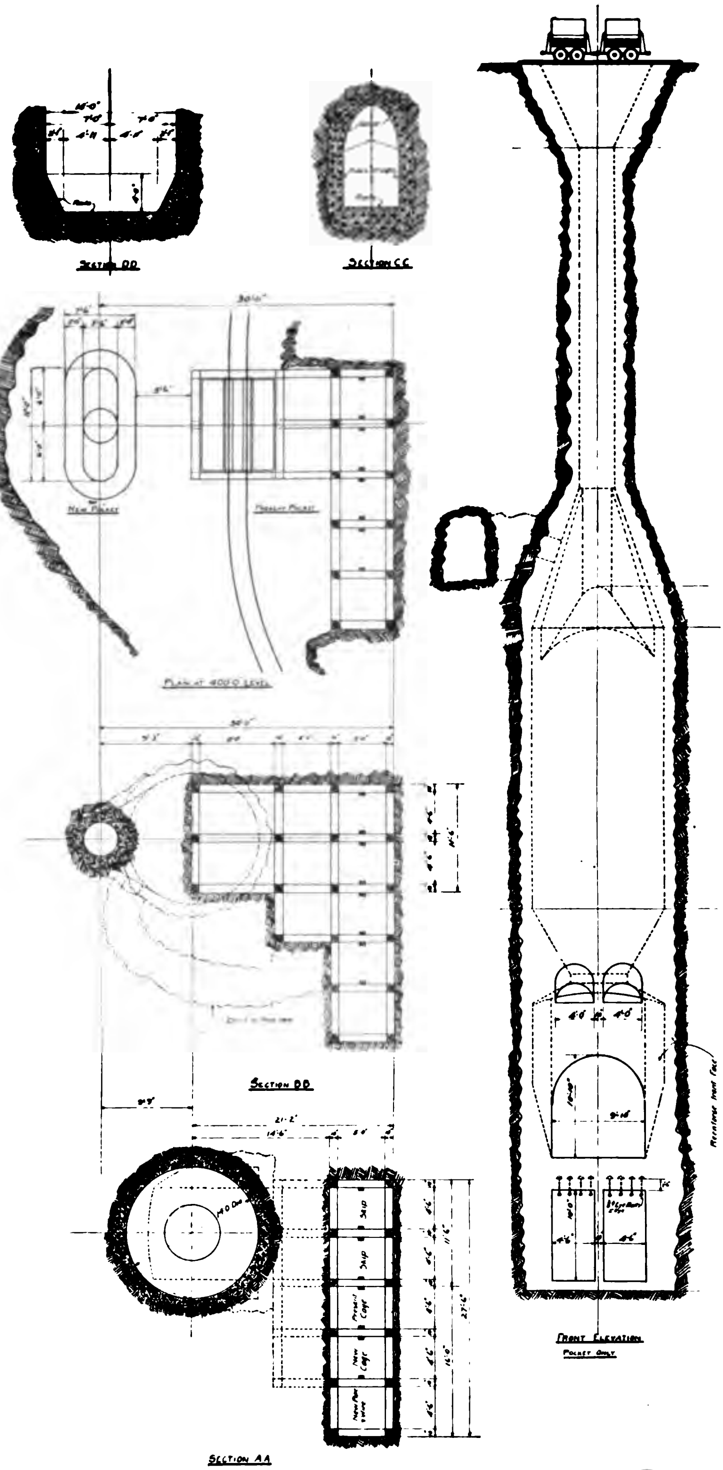


FIGURE 7. SKETCH OF CONCRETE POCKET BUILT PARTICULARLY TO HANDLE STICKY ORES FROM THE DIVIDEND SLICE.

territory has been very expensive and it has been almost impossible to complete a section successfully. As a preliminary to starting the slice, a drift was driven in the footwall on the


Section DD
Section CC
New Pocket
Present Pocket
Plan at 4000 level
Section DD
Skip
Skip
Present Cage
New Cage
Section AA
Front Elevation
Pocket Only

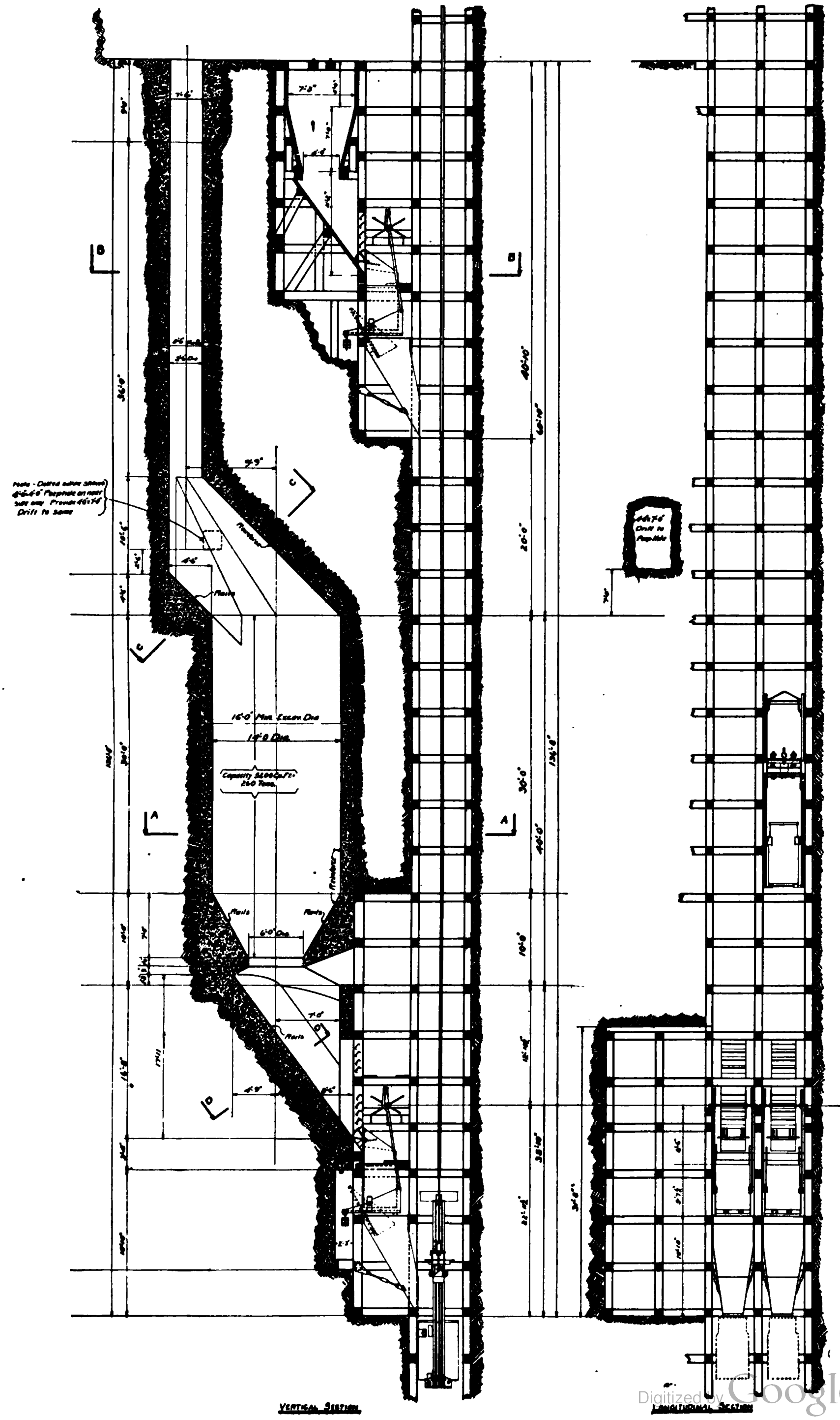
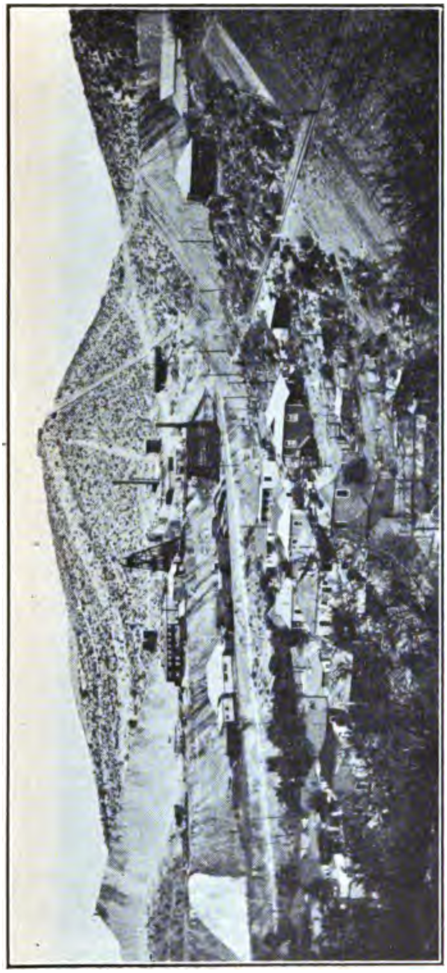


FIGURE 8, TWO PARTS, SHOWS CONCRETE STORAGE POCKET AT THE 400 FT. LEVEL OF THE SACRAMENTO HOISTING SHAFT DESIGNED TO HANDLE WET ALUMINOUS ORES. CAPACITY 260 TONS.

400-ft. level; the orebody lies on the footwall and extends up about 50 ft. above the 200-ft. level. Raises were then put up to the 200-ft. level in the footwall; it has been found that raises in the orebody will not stand the immense pressure which is brought to bear upon them. Because the ore is very wet and aluminous, it is hard to handle in the chutes, and concrete pockets have been designed which have the shape of an inverted funnel, with the large portion of the funnel downward. About 30 ft. above the 400-ft. sill, or in the top of this funnel, an offset or baffle has been put in, and from this point the raise is continued to the 200-ft. level. The raise is circular and is lined with concrete. While we have not yet proved that this type of pocket will be successful, we are confident that it will very considerably lower the cost of handling the ore. The work in this orebody has not progressed to a point where a comparison of costs may be made, but we are quite certain that the operation will be successful.

One advantage of top-slicing is that it is very elastic. Drifts for prospecting may be driven in any direction from any floor, and the waste disposed of in the workings. Another advantage is that in mining the orebody from the top down, the ore is mined clean, and still another is that wherever it is desirable, incline raises may be put up at any point from main raises to the mining floor to lower the cost of tramming. Several orebodies in the Czar, Holbrook, Gardner and Sacramento mines are being developed upon this plan, and the management is of the opinion that they will show a substantial lowering of costs, as compared with those worked by square-setting. It must be understood, however, that top-slicing can be used only where it will not damage any portion of the mine, and, particularly, it must be demonstrated, as before noted, that there are no orebodies above the territory worked according to this system.

Conclusions as to Mining Systems—It is quite evident to the writer that in future developments in these properties, wherever orebodies are developed which are adapted to top-slicing, cut-and-fill, or shrinkage methods, these methods will be found to be much more economical than the square-setting which has been in vogue almost exclusively in the past. It must be remembered, however, that the square-set method will always be used for a large portion of the ore in these properties, because it undoubtedly has some advantages under varying conditions that the other systems do not have.



F. HEAD FRAME OF LOWELL MINE AND NEW AIR BALANCING EQUIPMENT ON THE RIGHT. COPPER QUEEN C. M. CO.

E. HEAD FRAME, CONVEYOR SYSTEM AND EXPERIMENTAL MILL AT SACRAMENTO MINE, COPPER QUEEN C. M. CO.

Ventilation—Until recently, natural ventilation aided by exhaust from drill machines and by small 5-h.p. blowers and compressed air was the only means of ventilating the extensive workings of the entire mine. While the temperature in stopes was not very high, the relative humidity in most places exceeded ninety per cent, and in consequence, the mine air seemed oppressive. A mechanical ventilation system was completed in the Gardner during August, 1913. The improved working conditions and increased efficiency of the men that have resulted have justified the installation of similar systems in the Lowell and Sacramento divisions.

The system of ventilation adopted in the Gardner is the pressure system. Two Sirocco blowers, located near the 900-ft. station, deliver a total of 70,000 cubic feet of air per minute. This entire volume of air is so conducted as to ventilate the workings from the 1000-ft. to the 600-ft. levels, from whence it exhausts through the shafts of the Calumet & Arizona Mining Company.

Lowell Fire District—In the Lowell division, there is an old fire which extends from the 1000-ft. to the 1300-ft. levels. Water is being run into this fire area. In working its way through the hot zone, this water becomes charged with copper sulphate. In a concrete precipitating plant, 500 ft. long and 4 ft. wide, on the 1300-ft. level these acid waters percolate among tin cans and scrap iron and thus deposit their copper.

To make secure the drifts and raises that conduct the gases which come from the fire district, those that are most important have been heavily lined with concrete.

Concrete Pockets and Raises—It has been found very economical for certain kinds of ore to put in concrete pockets and cylindrical raises in storage chutes; the up-keep cost of concrete is practically nothing, whereas the maintenance of timber in storage chutes is expensive.

Copper Queen—An interesting feature of the mine is that at present large areas of old stopes are being worked, and ore which was regarded as waste in former years is now mined at a profit. A large amount of this work is being done in the Czar and Holbrook divisions.

During 1913 about 104.000 ft. of development work was done, about 70,000 ft. of it on contract. The timber used for the year was 18,645,713 feet.

The output for the year was 867,481 tons of copper ore, yielding 97,181,725 pounds of copper, and 15,573 tons of lead ore, yielding 5,701,628 pounds of lead. To January, 1914. the mine has produced a total of 1,176,718,905 pounds of copper.

B. DIVIDEND INCLINE OF CZAR MINE, COPPER QUEEN C. M. CO.

THE SINKING OF A VERTICAL SHAFT AT THE PALMS MINE OF THE NEWPORT MINING CO., AT BESSEMER, MICHIGAN.

BY FRANK BLACKWELL, IRONWOOD, MICH.*

Before the sinking of the shaft at the Palms mine was begun, the management made a detailed comparison of the advantages and disadvantages of incline and vertical shafts in the footwall. An incline shaft would have the disadvantages of rails, back runners, skip wheels, axles and boxes, and the expense and trouble of axle lubrication, and of frequently replacing supports for ropes; longer ropes would be required, and wear and tear of same would be greater, and the skips would have to travel a greater distance and at limited speed. There would be a constant and considerable expense for the upkeep of the shaft and its equipment. A vertical shaft in the foot-wall would have only the disadvantages of longer cross-cuts from the orebody to the shaft, and of the greater distance of transportation; but with transportation by electricity, distance is a small consideration. Accordingly a vertical shaft was decided upon, to be lined with steel and concrete. (Fig. 1.)

DESIGN OF SHAFT.

The shaft is divided into five compartments: a cage compartment 6ft. 2 in. by 10 ft.; two skip compartments 4 ft. 10 in. by 6 ft. each; a ladder compartment 3 ft. 8 in. by 4 ft. 10 in.; and a pipe and counterweight compartment 3 ft. 8 in. by 4 ft. 10 in. (Fig. 2.) It is 10 ft. 10 in. by 17 ft. 6 in. in outside dimensions. The wall plates, 17 ft. 6 in. long, and the end pieces and the two dividers, each 10 ft. long, are 5-in. 18.7-lb. H sections. The other two dividers, 4 ft. 10 in. long, are 4-in. 13.6-lb. H sections. The

*Mining Engineer.

eight studdles are 3 in. by 3 in. by ¼ in. angle iron. Most of the sets are placed 8 ft. apart center to center. Because of the heavy ground encountered several sets are placed 6 ft.

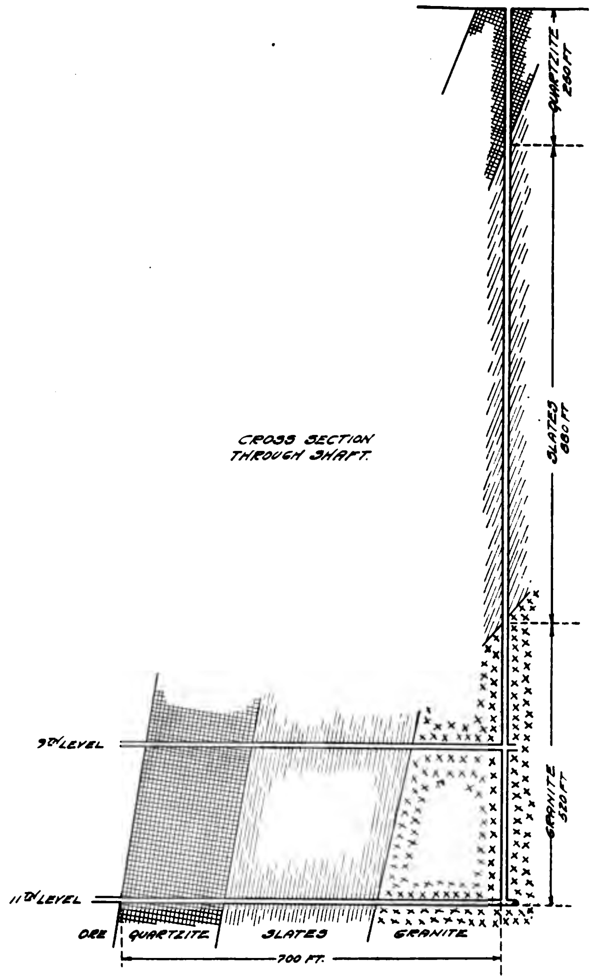


FIG. I

Figure 1 Cross Section Through Shaft

apart, and a few of them 4 feet. The wooden guides are 5¾ in. by 7¾ in.; two of them are strengthened by 7-in. channel iron.

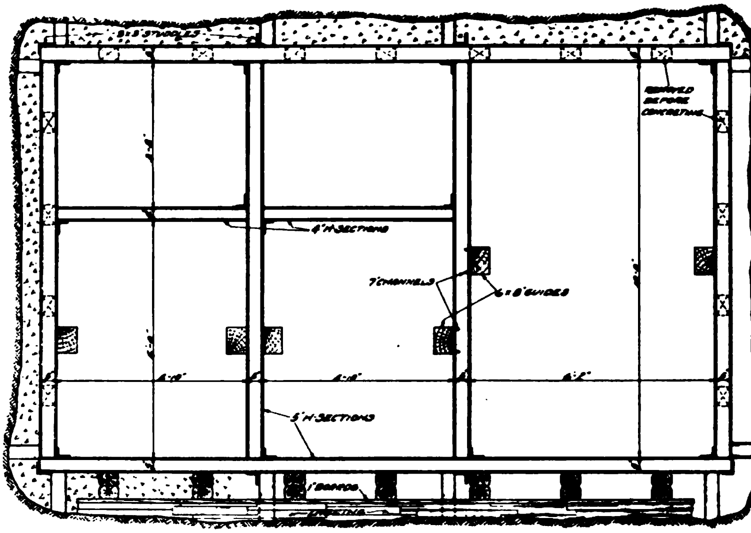


FIGURE 2 PLAN OF SHAFT

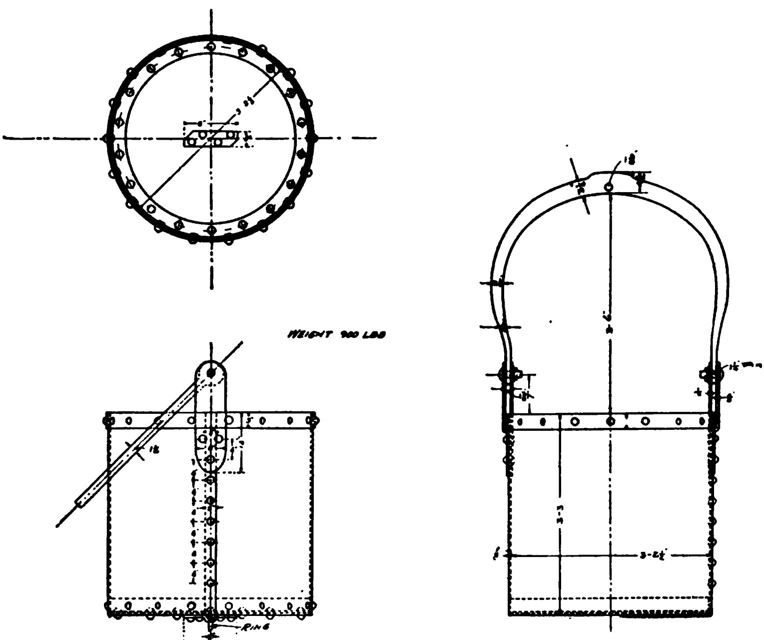


FIG 3

FIGURE 3 BUCKET USED FOR SHAFT SINKING

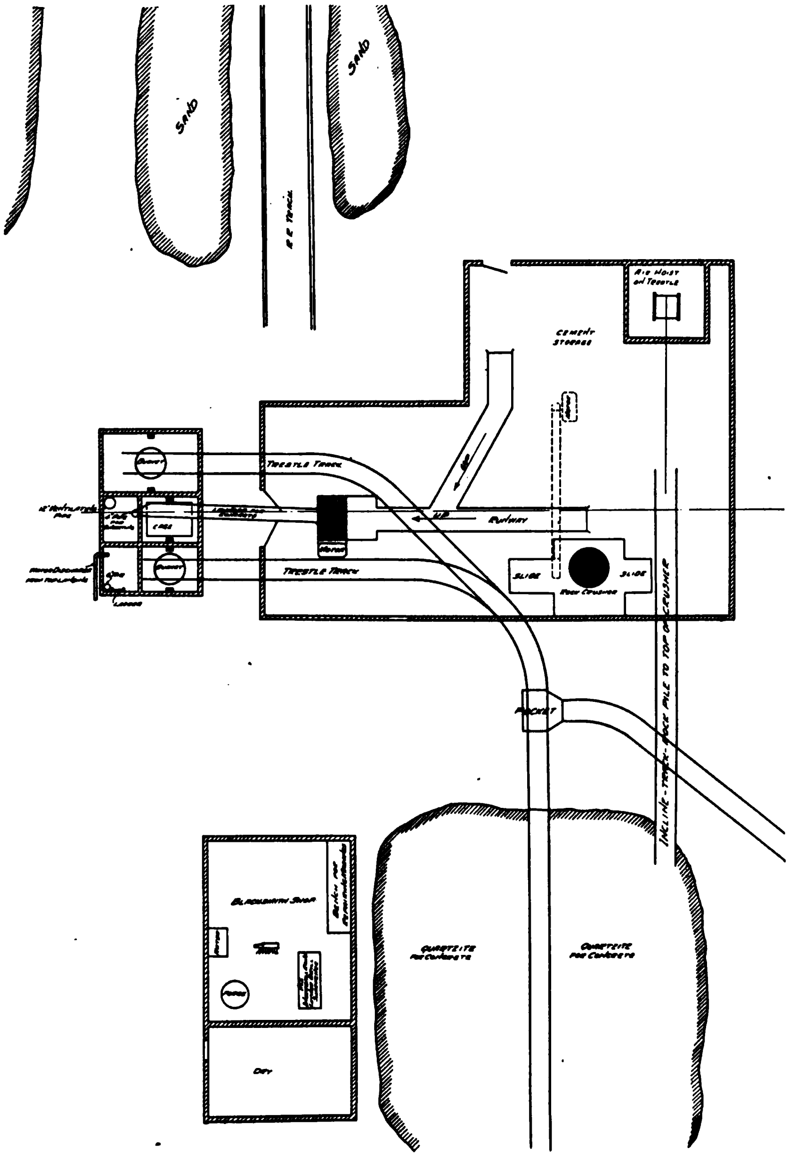


FIGURE 4 GENERAL SURFACE PLAN

EQUIPMENT FOR SHAFT SINKING.

The temporary headframe used was high enough so that the bucket of rock could be dumped into a car 18 ft. above surface. After a bucket (Fig. 3) was hoisted, a counterweight door was let down and the car run upon it. A chain was hooked to the bottom of the bucket so that when the bucket was lowered it dumped its contents into the car. The quartzite in the shaft was dumped from the trestle and reserved for concreting. (Fig. 4.) For crushing the rock for concreting a Gates gyratory crusher No. 2, driven by a 20-h.p. motor, was used.

Near the shaft was the shop, (Fig. 4) where the drills were sharpened and the drilling machines repaired. For sharpening the drills, an Ingersoll-Rand No. 5 Leyner drill sharpener was used. The die accompanying this machine very easily shanked the drills for use in the jack-hammers. The bits ranged in size from 1¼ to 1¾ inches. At one end of the shop was located a small dry and, conveniently near, a powder house.

In the temporary engine house was a double-drum double-gear-reduction electric hoist, the drums 40 in. in diameter, and with 30-in. faces, designed for a total load of 6,000 pounds, and with an average rope speed of 600 ft. per minute. The motor was 70-h.p. with a speed of 550 rev. per minute. This operated the two 26-cu.-ft. rock buckets in the two end compartments of the shaft with a ¾-in. rope, usually in balance. Here was also a geared single-drum 50-h.p. electric hoist, with a drum 2 ft. 6 in. both in diameter and in face, and operating with a ¾-in. wire rope a light cage for timbermen in the middle compartment of the shaft. The same engineer fired a small boiler which heated the entire surface equipment for shaft sinking.

For ventilation a 12-in. pipe, which still remains in the shaft for the cage counterweight, was connected to a 7½-h.p. electric fan. The pipe extended down to within 15 or 25 ft. from the bottom of the shaft. Immediately after the blasting, compressed air was blown into the shaft through a valve on surface, and the fan started. The smoke and gases were drawn through the fan in this way for about half an hour.

To the bottom end of the air line was connected a flanged fitting with eleven ¾-in. valved outlets for hose connections. Before blasting, this fitting was replaced by a flanged reducer having a ¾-in. valve opening. The timbermen also used this for a hose connection for running the auger machine.

SINKING THE SHAFT.

Forty holes were drilled per cut; ten Ingersoll-Rand jack-hammers and four spares with ⅞-in. hollow hexagon steel were used. In the soft slates 8-ft. holes were drilled. During the drilling the holes were cleaned out with a blow-pipe. This was found to be indispensable for rapid drilling. When the drilling was nearly completed, only about four of the machines were running; the other men were preparing the explosives and removing air hose.

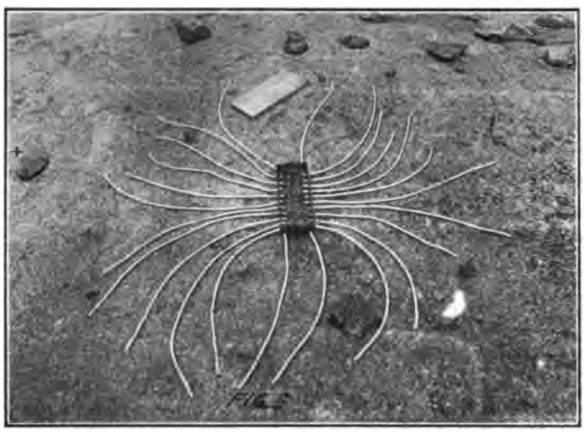


FIGURE 5 BLASTING BOX

Figure 5 shows the blasting box used. This was a paraffined pasteboard box 9 in. by 3½ in. and 1½ in. deep. With an iron punch, holes just large enough for a fuse to fit tightly were made in the sides of this box near the bottom. In the first boxes used, a positive wire was led through one end and a negative through the other. The ends of these were connected with a one-ampere fuse. Two of these boxes were used at the same time to blast a whole cut. Two positive wires, one for each box, of copper, No. 14 gauge, were strung from surface, and the two negative wires were connected to the air pipe. After fuses of proper length were inserted through the holes in the box, a small amount of a mixture of FF rifle and ordinary blasting black powder was strewn over the one-ampere fuse, and the box covered with a wooden lid. When the men reached surface, they could determine positively by means of a galvanometer whether they had made the wire connections properly, and whether the circuit was closed. Then the 250-volt current was thrown on, and the one-ampere fuse burned and ignited the powder, and this, in turn, ignited the fuses. If only a few of the fuses spit fire at first, these in turn ignited others, and almost instantaneously all the fuses threw fire across the inside of the box, so that it was almost impossible for any one to miss fire. The fuses were cut to such lengths that only one hole went off at a time.

However, too much labor was required to prepare these one-ampere fuse boxes, so that later an electric blasting squib was used to ignite the powder in the box. A squib was placed through a hole at each end of the box, two being used to insure the igniting of the black powder. The two boxes were connected in series, with but one No. 14 positive copper wire from surface, and with the negative wire connected to the air pipe. Finally, a Du Pont delay electric fuse-igniter was used in place of the squib.

Du Pont 80-per cent gelatin 1 in. by 8 in. was used for blasting. For a 7-ft. cut, from 250 to 300 sticks were used; for a 5-ft. cut, from 200 to 250 sticks were used.

After the blasting, when the smoke had been blown out, the miners cleaned down the sets, trimmed the sides, and began mucking. Toward the end of the mucking some of the men used one bucket to lower the hose, machines, tools, etc., for the next cut, while the other men picked the bottom thoroughly and finished mucking with single hoisting.

PLACING THE SETS.

Some of the steel sets were riveted together on surface. Where the rock was sufficiently hard so that a distance of 14 ft. underneath the last set was available, the set was lowered entire and swung into place. Shoes on the two lower corners guided it through the shaft. Four one-ton duplex chain blocks were used for swinging it into place. To each corner of the set was fastened a ½-in. sling chain about 3 ft. long, with a 5-in. ring on one end and a 3-in. ring on the other, and to these the hooks of the chain blocks were attached. If the distance under the last set in the shaft was less than 14 ft. the sets were lowered in parts and bolted together in the shaft. For blocking the sets a supply of wood sprags of different lengths was always ready on surface for immediate use.

When the solid rock (Figs. 2 and 10) was more than 8 or 9 in. from the steel sets, 4-in. tie timbers were placed vertically 4 in. outside the sets and about 2 ft. apart. Between the steel sets and these timbers 4-in. wood blocks 12 in. long were placed. One-inch rough boards were placed horizontally

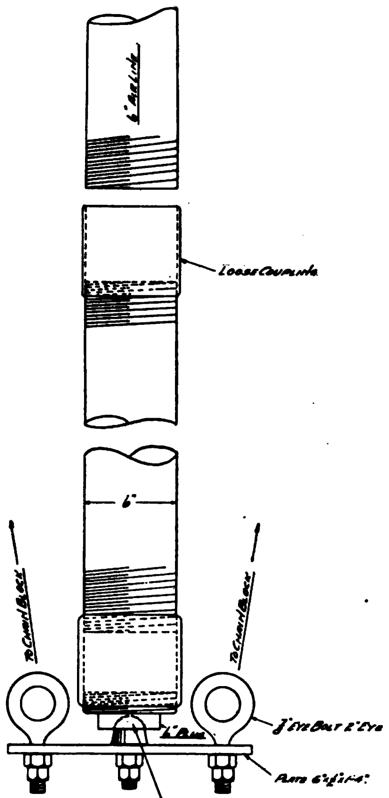


FIG. 6

FIGURE 6 METHOD OF CONNECTING AIR LINE

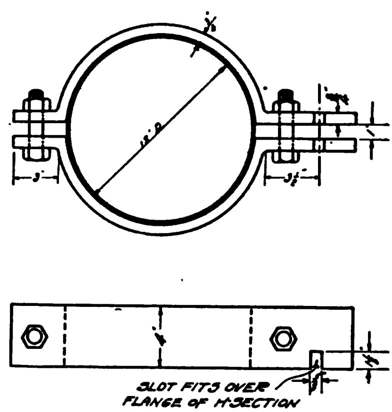


FIG. 7

FIGURE 7 METHOD OF SUPPORTING PIPE IN SHAFT

outside the verticals to act as outside forms for pouring concrete. Lagging was filled in between the boards and the solid rock. When the rock was less than 8 or 9 in. from the sets, 4-in. flat timbers were placed between the flanges of the H section sets, and lagging placed behind to the rock. (See Figs. 2 and 10). This lagging was left until concreting time, when it was removed and hoisted to surface. In the two ends of the shaft the rock was from 2 to 8 in. from the steel sets for nearly the whole distance. In the other two sides the rock was 9 in. or less from the wall plates for about one-half the whole distance.

A length of pipe was connected to the bottom end of the air line as follows (Fig. 6): Tó the top end of the section that was to be lowered, a coupling was fastened very loosely by a very few threads, and to the bottom end was attached a temporary coupling with the socket of a ball-and-socket joint. The pipe was lowered underneath the bucket with a half-inch chain.

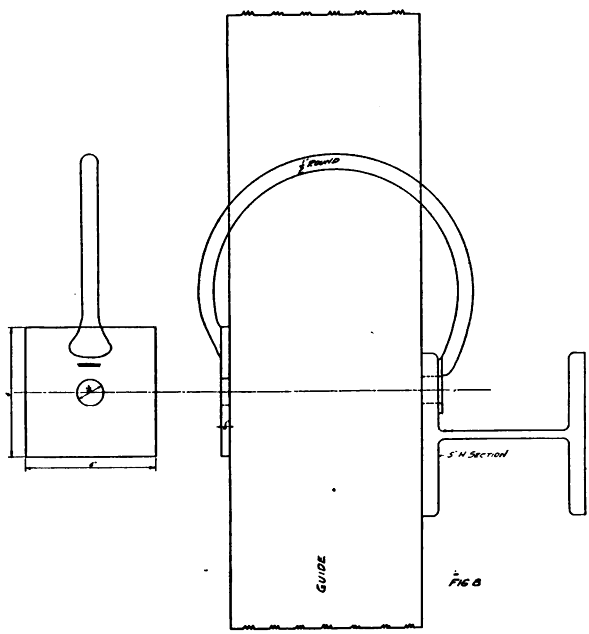


FIGURE 8 DEVICE FOR CENTERING HOLES TO BE BORED IN GUIDES

A clamp kept it from slipping. The plate of the ball-and-socket joint was supported underneath the air line by two chain blocks. The lower end of the section of pipe was swung over upon the plate by hand. The chain blocks raised the section of pipe up to the end of the air line. Then with a few turns of the loose coupling by hand the connection was quickly made. The coupling was tightened with chain tongs. In the couplings every 40 to 50 ft., ½-in. air connections were made.

To lower a section of the 12-in. flanged pipe the bucket was removed from the hoisting rope; eye-bolts were inserted in three of the holes of the flange, and rods connected these eye-bolts to a ring in the clevice at the end of the hoisting rope. At the end of the 12-in. line two chain blocks were hung and by means of two ¾-in. wire-rope slings the section of pipe was taken from the hoisting rope and placed in the proper position for connection to the 12-in. line. Fig. 7 shows the method of supporting this pipe in the shaft. The slot engaged the flange of the H section sets. Every alternate one of these rested upon the wall plates and the others upon the dividers.

The guides were lowered either in or underneath the bucket. When the proper depth was reached, a sling chain was

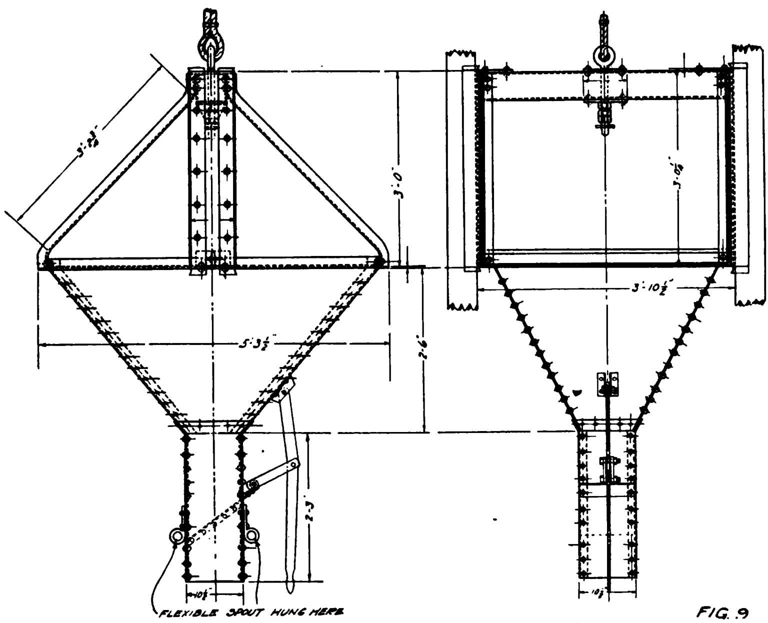


FIGURE 9 HOPPER FOR LOWERING CONCRETE IN SHAFT

fastened around the guide and a chain block hung to the set swung it into place. In lining the guide a 2- by 2-in. wooden gauge was placed between the wall plate and guide. This gauge was supported by two hooks hung over the flange of the H section divider or end piece. The bolt holes were bored after the guide was lined up. In order to start the hole directly opposite the hole already drilled in the steel set, the device shown in Fig. 8 was used. The hole for the bolt head was counter-bored by hand with an extension bit, and the bolt hole was bored with an air auger machine and twist drill.

CONCRETING.

During the sinking, every 75 to 100 ft. two or three adjacent sets were filled in to the solid rock with concrete; this made it unnecessary to cut hitches and place steel bearers. This concrete also serves as a permanent support to the shaft. It was mixed on surface and lowered in a hopper (Fig. 9) at the bottom of which was a flexible spout. (Fig. 10).

When the shaft was sunk to a depth of 1207 ft., it was thought necessary to complete the concreting because of the approach of cold weather. Concreting was started at a depth of 1170 feet. The concrete was mixed in the proportions 1-3-5 in a half-yard electric driven mixer (Fig. 4), and conducted through a launder to a 4-in. flanged pipe laid from surface. The lower end of the 4-in. pipe telescoped into a 5-in. branch (Fig. 10). This 5-in. branch took the blow of the concrete. To the bottom of the branch was connected a reverse bend with its lower end vertical. A flexible spout 18 ft. long which fitted over this conducted the concrete to the forms. While the concreting force was filling one set, other men were removing the blocking from the set above as explained, hanging the strands of old wire rope vertically one foot apart and horizontally about three feet apart for reinforcement, and placing the inside forms. For an 8-ft. span, 2-in. hardwood plank was used, (Fig. 10), and for 4-ft. and 6-ft. spans, 1⅝-in. hardwood plank. The plank was cut on a bevel on the upper end, so that the concrete came underneath the steel sets for a support. The bottom end came tight against the outside flange of the H section. Two-inch strips of wood about 12 in. long were laid one inch apart between the bottom end of the plank and the inside flange of steel. When these strips were taken out the planks were easily removed from the concrete.

In all cases the corners were left open for a distance of at least 12 in. from the corners of the sets. (Fig. 2). This left a solid column of concrete in each corner for the entire depth of the shaft. Also where the lagging and timber was left between the concrete and rock, openings for concrete were left Thus in all cases the concrete extended from the steel set to directly back of the wall plates and end pieces to the solid rock. the rock (Fig. 10). A 6- by 8-in. block 12 in. long was laid in the concrete midway between the 8-ft. sets to serve as a support to the two end guides.

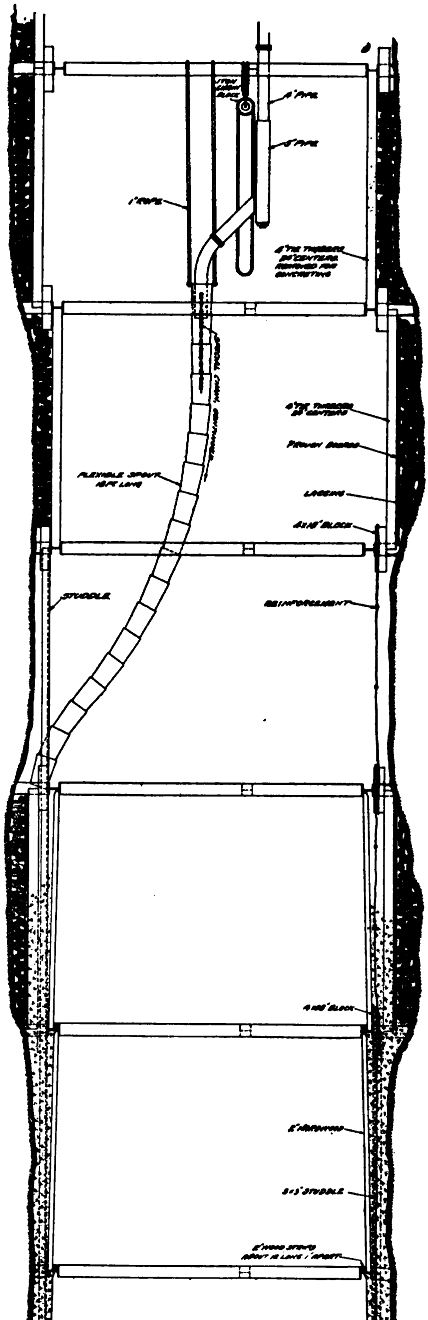


FIGURE 10 METHOD OF LAGGING SETS AND CONCRETING

WATER.

Most of the water entered the shaft at 15 ft. from surface, and a concrete dam built about 100 ft. down collected most of it. When the dam was full, the water was run into a bucket through an opened valve and hoisted to surface. The water in the bottom of the shaft was also handled in buckets. On the trestle landing a wheeled water tank was pushed underneath the bucket.

LABOR.

The day was divided into three 8-hour shifts. Nine miners and a foreman per shift did the drilling, blasting and mucking, and assisted the timbermen in placing the sets, concrete bearers, and 12-in. pipe.

Three timbermen per shift for three shifts with two foremen for the 24 hours lagged the sets, put in the guides, extended the air line, placed the ladders, and substituted for absent miners, etc. During 24 hours two engineers operated the double-drum hoist, and two the single-drum. There were two top-landers per 12 hours and two men to handle the rock, tram, move track and level the stockpile ground. Two blacksmiths were engaged during 24 hours with a helper for one shift. After each cut was drilled all of the machines were taken apart for inspection and repairs and oiled. This required a mechanic for a few hours each day.

The concreting required the ten miners for removing lagging, placing reinforcement and placing plank forms. The four timbermen attended to the distribution of the concrete to the forms. On surface three men wheeled rock to the mixer, two men the sand and cement, one poured water and attended to the securing of the proper mixture, one discharged the mixer, one looked after the launder from the mixer to the 4-in. pipe and two men conducted the concrete down the 4-in. pipe. All the men worked 8-hour shifts on the concreting.

The approximate time required for a 7-ft. cut was as follows:

	Hours.
Drilling	4
Hoisting tools and blasting	1
Blowing smoke	½
Lowering men and cleaning off sets	1
Trimming the sides	1

Mucking and picking bottom	14½
Placing a set	2
Lunch	½
Changing shifts	¼

For extending the shaft equipment the approximate time required was as follows:

	Hours.
To lower and place one length of air pipe	¾
To lower and place one length of 12-in. pipe	1
To lower and place one length of guide	¾
To lower and place one length of 7-in. channel	¾

Concreting during sinking required two shifts to make a plank bottom and fill between three adjacent sets or 16 feet.

The speed of sinking the shaft, including the placing of steel sets and lagging, occasional concreting, etc., averaged from 4 to 4.56 ft. per day during several months. For the last three weeks in August, 1913, it averaged 5 ft. per day.

The speed of final concreting was from 35 to 48 ft. per day. For the total distance concreted 78 gondolas of sand and 15,695 sacks or 21 carloads of cement were required.

The above is a description of the shaft sunk to a depth of 1207 feet. During the sinking a raise 5x12 ft. also was driven 285 ft. from the 11th to the 9th levels; and then 158 ft. above the 9th level. Here it holed underneath the shaft. Stripping then progressed down to the 11th level; with pockets installed at the 9th level. The shaft is now 80 ft. below the 11th level, but is concreted only to a depth of 1170 ft. below surface.

During the entire shaft sinking not a single serious accident resulted. Great credit is due the men for the versatility of their suggestions, their willing application to the work, and interest they manifested in the speed and general progress of the shaft sinking.

DISCUSSION.

MR. BLACKWELL: There are one or two things I might say about the paper. All the shaft sinking in the foot-wall on the Gogebic Range has been on the incline, and this is the first sunk vertically.

I want to emphasize the use of the blasting box. By means of it the speed of the shaft sinking was increased by 55 per cent. This box can also be used in high raises. Instead of using a long fuse for each hole, one long fuse can be used to ignite the powder in the box, which in turn ignites all the short ones leading from the box to the holes. This has been used successfully.

MR. EATON: I should not think that studdles made of 3x3x ¼ angle iron would be heavy enough. I should think that after the bearers were in, there would be a great deal of compression on the studdles when the ground settled.

MR. BLACKWELL: While sinking there were incline sprags placed underneath occasional sets, which support the weight which would otherwise come upon the studdles. Finally the concrete lining incloses these studdles so that they act as a reinforcement, and the concrete supports all the weight.

MINING METHODS ON THE MARQUETTE RANGE.

BY COMMITTEE CONSISTING OF H. T. HULST, G. R. JACKSON, W. A. SIEBENTHAL.

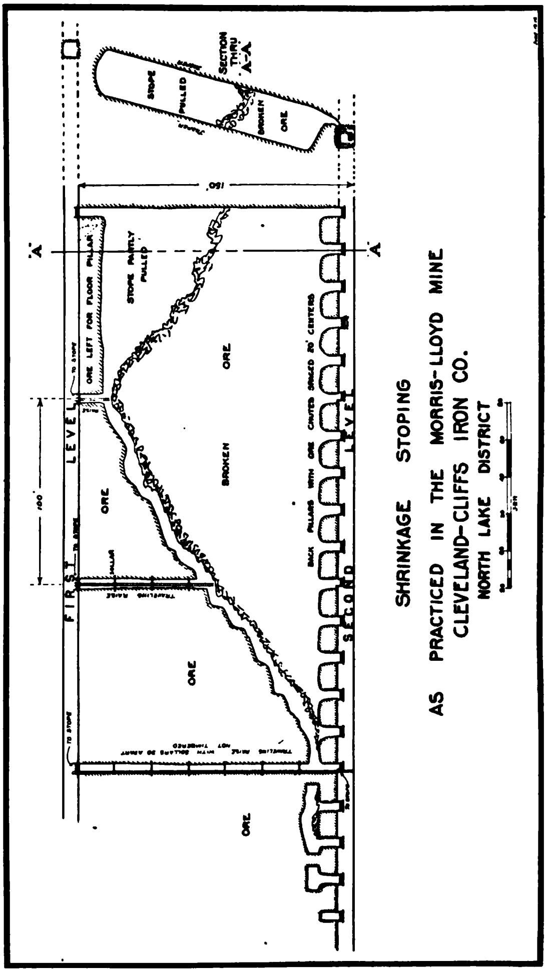
SHRINKAGE-STOPE SYSTEM.

At the Lloyd mine of the Cleveland-Cliffs Iron Company, a form of the shrinkage-stope system has been followed in mining a part of the orebody. A silicious orebody 500 ft. in length, and from 25 to 75 ft. in width, and from 50 to 175 ft. in thickness, has been taken out according to this system. Because it forms the hanging of a narrow high-grade orebody, it had to be mined first. Furthermore, if it was to yield a profit, it had to be mined cheaply. After a study of conditions, the shrinkage-stope system was selected.

The formation in the North Lake district stands at a steep angle, the dip varying from 70 to 85 degrees. In using this system of mining, there was no danger from falls of ground from the back, but special attention had to be given the hanging side of the stope.

The shaft is located in the footwall 300 ft. away from the ore, this site having been chosen on account of the location of the loading tracks. Levels were opened 150 ft. apart and crosscuts were driven from the shaft to the ore. Drifts were driven in the ore both ways with the formation to the limit of the orebody. These drifts were timbered with sets four feet apart, 8-ft. legs and 7-ft. caps being used. The orebody was developed by crosscuts turned off every 100 ft. to determine the width and grade. The main haulage drift was driven near the footwall, in the wide part of the deposit; a parallel drift was later driven near the hanging, as the orebody was too wide to be removed in one stope. Up to widths of 40 ft. the ore was removed in one stope; greater widths were taken out either in a parallel stope with a pillar between, or by stopes at right angles with pillars between. This latter method was used where pockets of ore extended into the hanging at points above the main level.

As the body was being developed on the main levels, raises



SHRINKAGE STOPING
AS PRACTICED IN THE MORRIS-LLOYD MINE
CLEVELAND-CLIFFS IRON CO.
NORTH LAKE DISTRICT

without cribbing were put up to the top of the ore every 100 feet. Above the 1st level these raises connected with each other at the top, and two raises were extended through to surface. The raises from the 2nd level were carried up to the 1st level and holed on the side of the haulage drift. These raises provided traveling roads to the stopes, ventilation, and a means of bringing in the air lines. Small raises without cribbing, with 15-ft. pillars between, were put up 10 ft. above the level in the main haulage drift. These raises were strongly built, being re-inforced with 40-lb. rails and 3-in. hardwood plank, because of the blasting of hang-ups. Chutes were built to these raises. At a point about 15 ft. above the level the raises were connected; the stope was then opened to full size and mining started. One gang of miners worked about 50 ft. of the stope, or the territory above three raises. Each miner had a raising drill, two machines thus being to one contract.

About thirty per cent. of the broken ore had to be drawn from the stope to make room for the men to work. One laborer was required to each 100 ft. of stope to sledge the large pieces. Occasionally it was necessary to block-hole large slabs which had been blasted or barred down from the hanging side of the stope. On the completion of the stope, the chutes were drawn as nearly equal as possible, as this seemed to prevent blocking.

This system of mining has worked out very satisfactorily as regards costs and safety.

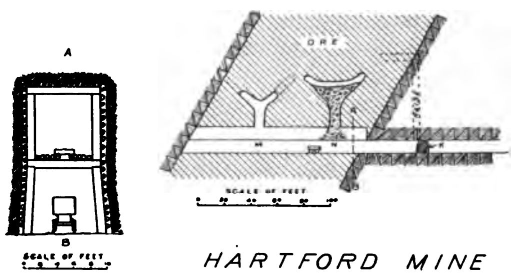
Stoping System Hartford Mine—Republic Iron and Steel Co.

A comparison of the methods of mining at the Hartford and Section 21 mines shows many points of similarity; the chief difference between them is that the Hartford employs overhand stoping, and Section 21 underhand stoping. The ore at the Hartford is peculiar as to its physical character, being a little different from any hematite heretofore produced on the Marquette Range. In consequence the usual methods of mining such deposits failed to give the desired results, so that considerable experimenting was necessary in the early stages of development to find the most economical system for removing the ore.

The room-and-pillar system was tried on the 750-ft level with but indifferent success, and was finally abandoned for the overhand-stoping and milling system modified and combined. In the developing of the orebody the ground broke in such large masses that it was almost impossible to keep the openings small enough so that standard sized drift sets could be used. Frequently a space of twelve or fifteen feet would open up between the timber and solid ground. As a result a prohibitive amount of lagging had to be used, and even then the drifts were always dangerous and expensive to maintain because of the breaking of timbers and blocking of the tracks.

To overcome this difficulty the openings were driven two sets high; little additional labor was required to break the ground to this increased height.

The illustration shows a cross-section through two of the stopes which were started from raises put up from a crosscut. The stope marked N is a little further advanced than M, in which the core has not yet fallen. No timber is used in the raises or stopes; thus no ladderways can be maintained in the openings through which the ore is milled. The working faces of the stopes are reached through the raises which are



SECTION ON A-B

HARTFORD MINE

CROSS SECTION THROUGH STOPES

put up at frequent intervals from the footwall drift marked K. The stopes themselves are also connected by small drifts entirely independent of the drifts from the raises, so that there may be half a dozen or more ways of entrance or retreat.

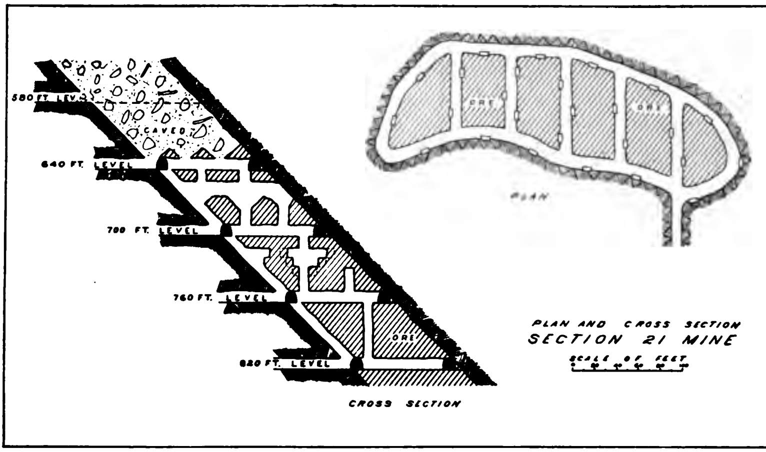
As the stopes advance, several may connect before the level above is reached. Where this happens, the conical shape is not continued, but the sides are carried up vertically instead; or one stope may be abandoned while the other is developed as originally started.

The section through the double-set drift shows a method of filling cars without using the chutes found in so many mines on the Marquette Range. The caps of the lower set of timbers are lagged over to an opening in the center directly above the track and this opening is covered with short pieces of timber which can easily be removed to let the ore into a car below. When any considerable tonnage falls away at one time from the core of a stope, masses several feet in diameter must be reduced to a size small enough to pass through the opening in the lagging. With the double-set drift these masses are always accessible, a few blows of a pick being all that is required.

SECTION 21 MINE—OLIVER IRON MINING CO.

In the western portion of Section 21 mine a stoping system is now used which has proved both economical and safe. The physical character of the ore is such that no timber is required except for the construction of chutes for handling the product when it is drawn from the mills.

In the opening of a new level, a crosscut is driven from



foot to hanging and both are then followed until the drifts connect. Crosscuts are usually driven between these drifts at distances of from 50 to 60 feet. Raising is started on the footwall as soon as development has advanced enough so that a chute can be operated without interfering with the other work on the level. The footwall raise is put up at this time chiefly for ventilation purposes and traveling way, as it is not needed for handling ore until later.

The ideal section shows a crosscut on 820-ft. level driven to the hanging with footwall raise completed, also another raise connected with the level above. Raises from the 760-ft. level show the system of milling; the dotted lines indicate the next step in advance. A floor pillar of six to ten feet is sufficient to support the level until all the available ore above it has been removed.

Between the 700- and 640-ft. levels a condition still farther advanced is shown, and on the 640-ft. level is shown the final stages of removing the pillars.

Practically all of the ore was removed to a depth of 350 ft. by this method without any apparent weakening of the hanging, but below this depth it has been necessary to modify the system so as to prevent caved rock from contaminating the ore. To accomplish this the pillars above the nearly exhausted level, as well as the floor pillars below it, are drilled and blasted continuously by fuse firing, with the result that the ore falls into the mills and is drawn from the chutes on the level below without any appreciable contamination.

All raises are vertical or nearly so, with the exception of the footwall raise and a few next the hanging. A plan of the workings just below the floor of each level, after mining has been started, would show a succession of circular mills of various sizes with a raise in the center of each. Numerous rock intrusions and dykes make it impossible to conform rigidly to any pre-determined geometrical plan further than to locate raises to reach the thickest portions of the pillars on the level above. Although the drawings show four levels in operation, this is not the actual condition in practice; instead, all of the various stages of development shown in detail are worked simultaneously over different parts of one level.

Method of Mining at the Republic Mine, Republic, Michigan.

BY R. B. WALLACE.

To illustrate the method of mining used at this hard-ore mine we will take as an example a body of ore averaging 20 ft. wide and 80 ft. long and extending several hundred feet in height. These "lenses," if we may call them such, do not always stand vertical, but may be inclined as much as 20 or 30 degrees.

The first step in extracting the ore is to drive a 7- by 7-ft. drift through the entire length of the orebody. The ore is then cut out the full size of the orebody to a height of 15 ft. and the stull over the tramway put in place. Breaking is then commenced and the ladderway mills are built up as is shown in Fig. 1. Fig. 2 is a longitudinal section through the stope showing the openings for drawing off the ore left every

25 ft. in the side of the timbered tramway. Only enough ore is drawn off to enable the miner to set up his machine.

In some places where the orebody is of greater length, this method has been modified, since the timbered tramways have to be renewed before the stope is finished. A drift is

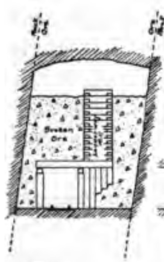


Fig. 1

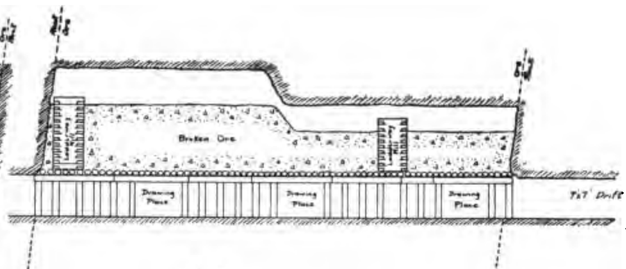


Fig. 2

run parallel to the orebody about 10 ft. back in the footwall and from this drift crosscuts are made every 25 ft. into the stope; through these the ore is drawn off and access is obtained to the ladderway mills. A cross-section through one of these crosscuts is shown in Fig. 3.

In the old workings are some floors which are being taken

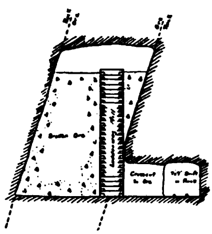


Fig 3

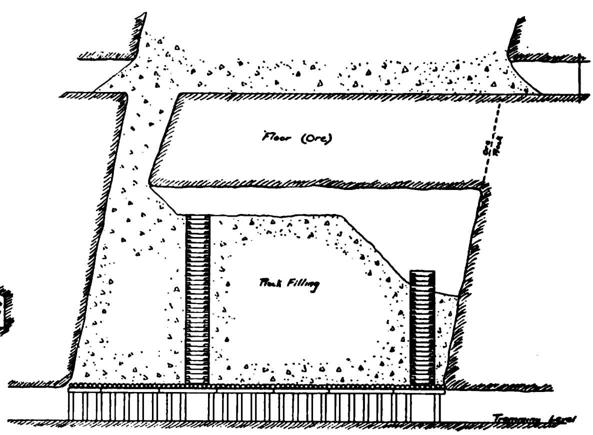


Fig 4

out. The process is slow, as the open stope below has to be filled with waste rock. There is an abundance of this and sometimes it is intermixed with enough ore from caved pillars and floors to pay for separating and handling the rock. Fig.

4 is a longitudinal section of a stope which is almost filled with waste rock preparatory to mining the floor. When the stope is filled to within 6 ft. of the back, breaking is commenced and the ore is thrown down the mills. More filling is leveled across the stope and the floor is thinned till finally it is broken through.

DISCUSSION.

MR. BLACKWELL: How is the ore graded when there is a pile broken in the stope?

MR. GRAFF: The ore is of one grade, and all low grade. It would be impossible to make more than one grade in the stopes.

MR. SPERR: As there are quite a number of miners present, mining captains and others, would it not be well to define what the shrinkage-stope system means. Is it what the miners know as stoping on arches and rigging up machines on the broken "dirt"? I have often wondered myself why it was called the shrinkage-stope method. I think this term of "shrinkage-stoping" is a good one because we are looking for terms to mean specific things in mining operations and this term is particularly well confined to a definite method of mining; but I doubt whether to many mining people who are not up on the literature of mining, the method would be suggested by the term. If we could invent terms that would mean something in practice as well as being specific, I think we would do the best possible for the literature of mining.

MR. GRAFF: I hardly know why that term is applied, because the stope is nearly full all the time; however, you have to shrink or pull it in order to get working room. That is my idea of why that term is applied to this system. The stope gets larger after each blast, and is filled more or less close to the back. It then has to be shrunk up by pulling some of the dirt from it in order that the men can get back to work.

MR. SPERR: But you do not shrink the stope by pulling some of the dirt from it. The stope is the excavation. What you shrink is the pile of broken material in the stope; you do not shrink the stope.

MR. GRAFF: Technically speaking you are correct in saying we shrink the pile of broken dirt in the stope, practically speaking, through virtue of common usage, we say "shrink the stope." As I understand it this is a meeting of practical miners and for that reason it would appear advisable not to be too severely technical.

Mr. Sperr: I am sure I could not attempt to add anything to further illustrate the method but I would venture the suggestion that it is a modified block-caving system. Most of the ore is cut off over a large area and as the cutting off proceeds upward and around, the block caves and then there is not only the central chute into which the ore may drop but all the other chutes which have been put up. In a general way the scheme is to cut the ore body off and allow it to settle into the chutes prepared for it, the same as in any block-caving method. To me it seemed a most desirable system and most admirably executed at the time I was in the mine.

Mr. Higgins: I would just like to say one word about these descriptions of mining methods; somewhat of a defense of the gentlemen who have written them, as a commendatory word. I want to say that for the past two years I have been investigating these methods of mining and have endeavored to describe them. I have read many descriptions of the methods and have noted that most of them do not present a perfect picture. I want to say I do not believe there is a man alive today who can describe these methods of mining, especially the highly complicated ones, and make them plain. I think these gentlemen have written splendid descriptions. The perfect picture can only be secured by trips underground.

Mr. Sperr: I think we would get a great deal from these papers, if we would get into the discussion of them and ask questions more freely than we do. Just as Mr Higgins says, there is no man on earth can put an underground operation on paper so that any man can understand it who has not seen it. I do not think I ever saw a better lot of papers than these are, but we do get wrong notions from the best of descriptions and for that reason I think that the papers should be freely discussed in order to derive the fullest benefits from these meetings.

Mr. Eaton: Is there anyone here who can tell how the ore is drawn off in the Republic mine, whether drawn into chutes or shoveled?

Mr. Pascoe: I would say the method we adopted here has been worked in the Republic Mine for several years, in this manner, which is, as Mr. Wallace in his paper, explains: all we do is drive our drift the length of the ore body and then cut it out to the full width of the ore body which averages from five to twenty-five feet in width, and to a height of sixteen feet. We then place our stulls underneath to a height of ten feet. Then we commence on the top of the stull and break our ore down. In order for us to take our ore from that stope we then have filling places, not mills, but filling places in the foot or hanging where we fill up under. On account of our ore being badly mixed we have to assort it underground. We fill it up under and have rock pickers who pick the rock out of the cars as it is filled. We draw off the excess ore about one-third while we are stoping. Then we continue that stope until we reach the level above, one hundred or one hundred and fifty feet. We mine this stope up within ten to fifteen feet through to the level above when we then commence on the extreme end and mine that floor through to the old workings until it is completely back to the extreme end, completing the stope. Then we start on the extreme end and blast the stulls down and draw the ore back. In that manner we keep on until we draw all the ore out or practically all the ore on that level. The next level we start underneath and if there is any ore left behind it would naturally drop down to the level below and I think it takes practically all the ore. It beats any method that has been adopted heretofore at the mine.

MR. JOHNSTON: What percentage of loss do you estimate?

MR. PASCOE: We have no loss to speak of, not over five per cent.

MR. ABBOTT: I would like to ask if he makes his fill with ore. Before the rock filling is made do you draw off all of the ore in the back?

MR. PASCOE: We take all the ore the first cut, then we put our stulls in from the center and then fill with the broken ore on each side and on top of that we start our mills, one on each end, inlet and outlet, and all the remaining parts of the stope we fill with broken ore.

MR. EATON: Is that ore thrown into the chutes by hand or is it drawn off?

MR. PASCOE: We do not handle it, we just draw it down.

MR. EATON: Do you draw it through the timber?

MR. PASCOE: No, we draw it down over the side. Our filling places are made on the side of the stulls. We do not use a chute on account of the ore being so badly mixed.

MR. EATON: Do you pick any of the rock out in the stopes?

MR. PASCOE: We do not pick any rock out until it comes into the car.

Mr. Kelly: The Republic Mine consists of several different ore bodies, some of which are rather small and there have been modifications in the methods of mining used in different parts of the mine. In the largest deposit now being worked the ore is taken out completely and no floor left between levels. That method of taking out the ore completely has been followed for something like a thousand feet in depth, leaving no floors in, the whole thing taken out completely. In this part of the mine in the working stopes the ore alone is used for standing on to break the back. In other parts of the mine it has been necessary to leave the floors under the old levels and in those places it has been necessary after taking out the stope of ore to fill it with rock in order to get the floor underneath the level above when that becomes available. A number of experiments have been made in handling the ore. Chutes were used for a time but in certain parts of the mine, as Mr. Pascoe stated, a good deal of the ore is more or less mixed with jasper and it is necessary to sort it out. Then too, some of it comes down very big and has to be blockholed. But where the ore is free and small enough a chute could be used to advantage. Some experiments have also been made in driving levels at different vertical distances apart. The usual distance has been one hundred feet but one hundred and fifty feet was tried in order to reduce the dead work of drifting. That has proven to be a little too much as it increases the difficulty of stoping and ties up too much ore. Since the introduction of Leyner drills the increase in speed and decrease in cost of drifting removes the disadvantages which previously were urged against the use of levels not exceeding one hundred feet in depth.

STEEL STOCKING TRESTLE AT NO. 3 SHAFT, NEGAUNEE MINE.

BY STUART R. ELLIOTT, NEGAUNEE, MICH.*

A common method of stocking iron ore is by the gravity system, extending the tracks on the pile of ore as it advances. The tracks are laid with sufficient grade to run the cars to the end of the pile. The cars are brought back either by a puffer or by trammers. For handling a large product this system is often not practical, as the necessary grade reduces the height of the pile and therefore its capacity. As the height decreases, the length of tram increases rapidly. The tracks are difficult and expensive to maintain and keep in proper alignment. Delays in hoisting are frequent and expensive. Also where the available stocking room is limited, often the gravity system cannot be considered. It has been proved at mines of large production that it is more economical to erect wooden trestles and to use some mechanical means of stocking. On the other hand, the cost each year for erecting and dismantling wooden trestles is heavy. With certain classes of ore the yearly breakage in legs will amount to as much as 3 per cent. An actual record kept of a trestle at a large mine shows that in six years not a single stick of the original timber was in use. The price of timber and trestle legs is steadily increasing and it is only a matter of a limited time when legs will be difficult to procure at any price.

For a number of years I have believed that it would be more economical to stock ore from permanent steel trestles. In 1909, when it was found necessary to sink a new shaft at the Negaunee mine, I began to collect data in order to make some preliminary estimates as to the comparative cost

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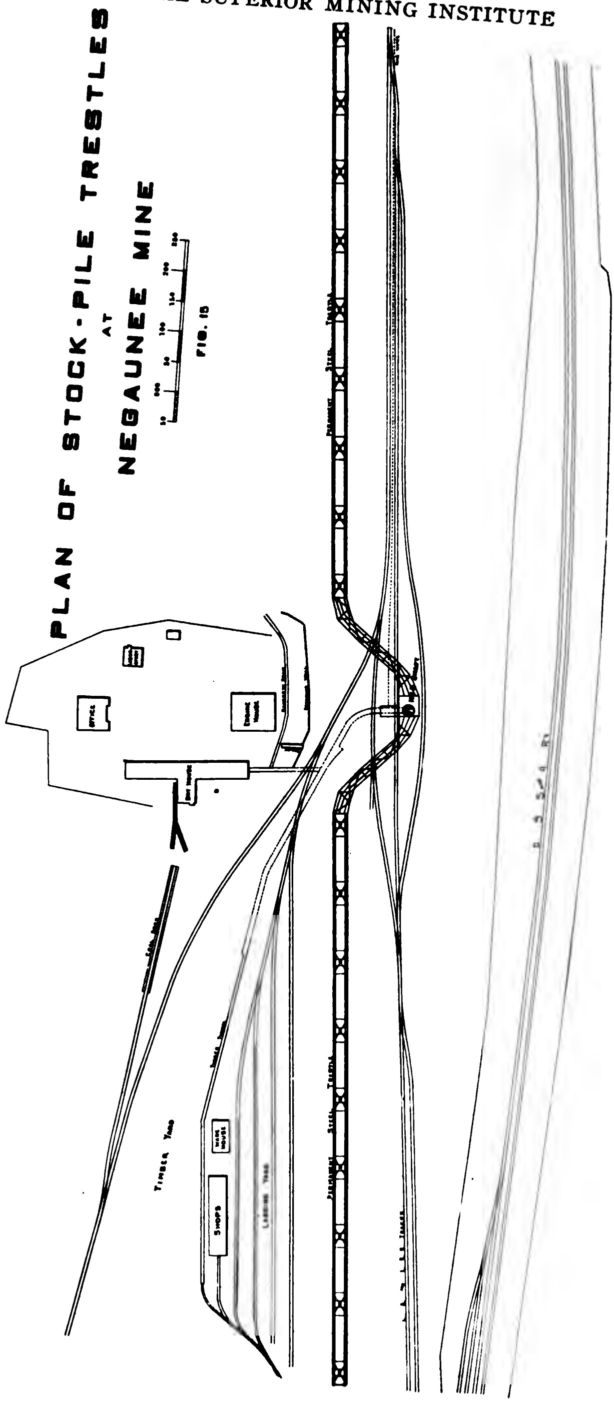
PLAN OF STOCK-PILE TRESTLES
AT
NEGAUNEE MINE
OFFICE
SHOPS
TIMBER YARD

FIG. 15

of wood and steel. I went to Milwaukee and submitted several sketches of steel trestles to Mr. J. F. Jackson, of the Wisconsin Bridge & Iron Company. When the cost of maintenance of wooden trestles had been explained to him, Mr. Jackson stated that it was his opinion that for a mine with a long life the cost of a steel trestle would not be excessive. He prepared some sketches and submitted approximate estimates of steel trestles. From these I was able to make some comparative estimates which showed conclusively that if a practicable steel trestle could be constructed, it would mean a large saving for any mine which had a life of ten years or more. The Wisconsin Bridge & Iron Company was asked to make final drawings and to submit bids for a steel trestle. These bids were accepted and the trestle constructed.

The average wooden trestle used by the Cleveland-Cliffs Iron company cost approximately $6 per foot. The cost for labor each year in erecting and dismantling amounts to $1.20 per foot, and the entire stocking trestle has to be renewed in about six years. A wooden trestle must be dismantled in order to load the ore with a steam shovel. It is not unusual during busy seasons for railroads to fail to supply mines with a sufficient number of cars to ship the current hoist from the shaft pockets; if this occurs after the trestle is dismantled, a great loss in time and money results from the delay. Even if a part of the trestle has not been torn down the ore can not be stocked by hand, because the modern top tram car is too heavy, and special cars would have to be provided. At other times the railroads are unable to supply the mines with cars because of strikes on docks or because storms delay boats and a shut-down therefore becomes necessary. A permanent steel stocking trestle would provide against all such delays, as the tracks would not have to be disturbed to load with steam shovels and it would therefore be possible to stock ore at any time at a minute's notice. On a steel trestle permanent tracks could be maintained in the best possible conditions for stocking; the tracks being in perfect alignment, no delays would be caused by cars falling from the trestle. For all of the above reasons, but particularly on account of the large saving in money over a long period of years, it was decided to install a permanent steel trestle at the Negaunee mine. The following is a description of this trestle:

At intervals of 114 ft. there are concrete columns, the upper part for a distance of 28 ft. 6 in. being 4 ft. in diameter and the lower 10 ft. belling out to a diameter of 6 ft. at the bottom. The shells of plate are ¼ in. thick. They rest on and are bolted to pyramid-shaped reenforced-concrete bases which are 12 ft. wide by 26 ft. long by 6 ft. deep. Each base is reenforced by 52 rods ⅞ in. in diameter which radiate in all directions through the base and extend up into the shells for a distance of 20 feet. (Fig. 1). The rods were all bent so as to extend to the proper points in the bases and to project to the correct height in the shells. In the bottom of each pyramid the rods were tied to seven old rails which extend across the long dimension. At a point about 20 ft. above the base

FIGURE 1 CONCRETE BASE AND RE-ENFORCING FOR COLUMNS

the rods were attached and properly distributed around two horizontal rings in the shells. Above these rings other rods were spliced so that the reenforcing extended to within a few inches of the top of the columns.

When the excavation for the base of a column was made and the form constructed, the rails and reenforcing bars were placed in position and wired to keep them from shifting. The six very heavy anchor bolts to which the steel shell is bolted were suspended from a templet and lined up by the engineers. In order to allow a small amount of leeway these anchor bolts were all set in sections of pipe. A concrete mixer was set over the edge of the excavation and the concrete dumped directly into the form. While one form was being filled the carpenters were busy constructing the form for the next base. In a very short time after one base was completed, the forms could be moved with safety to the next excavation. In this way only a small amount of lumber was used. Before the bases were completed the bridge builders were on the ground and ready to begin placing the steel shells in position. For handling the heavy steel, a railroad track had been laid along the entire length of the trestle.

The length of span between columns is 114 feet. Across the center of each column are two short plate girders, each 38 ft. in length. Between these short girders are two other girders 76 ft. long, thus making the total span of 114 feet. As soon as one span was bolted together two shells could be filled with concrete. A puffer, operating two small steel cages in balance, was set up midway between the two shells, thus filling them simultaneously. To one end of the drum of the puffer was attached a spool, and around this spool a 5/8-in. wire rope was wrapped four times. The ends of the rope extended from the spool at an angle of about 30° to sheaves supported about 6 ft. above the top of the shells. The cages were constructed to run on wire-rope guides from the ground to the top of each shell, the rope serving simply to keep the cages from twisting. The hoisting rope was so adjusted that when one cage was on the ground the other was above the shell. Concrete was loaded in small concrete buggies holding about a quarter of a yard. The work progressed rapidly and at a reasonable cost. As it was feared that the dumping of the material might throw the columns slightly out of line if the shells were filled completely in one operation, they were filled a little over a half full one day and completed the following. After the shells were filled the surface was rounded off with a rich mixture and made as smooth as possible, to keep water from getting between the concrete and the steel jacket. The work was constantly watched by an engineer to see that the shells did not shift or get out of alignment.

On top of each column the girders rest on horizontal 8-in. I-beams supported by four braces firmly connected to the columns which extend down at an angle of 45 degrees. The plate girders are made up of angles and two plates 42 in. wide and 1/4 in. thick. The distance from center to center of girders, or center to center of tracks, is 20 feet. The entire length of the part of the trestle from which ore can be stocked is 2,094 feet. In addition there are 500 ft. of curved trestle extending from the shaft and connecting with the stocking trestle. The legs in the curved part are built up of angles and channels. The stringers are channels and I-beams of various sections. On top of the I-beams are holes to which are bolted 5-in. nailing strips. On top of these nailing strips was spiked a 5- by 7-in. sollar to serve as ties. The 40-lb.

COMPLETED TRESTLE

rails on the plate girders are spiked to 5-in. sawed ties 4 ft. in length. On the outside of the girders the ties were bolted to 4- by 4-in. timbers placed snugly up against the girders. These 4- by 4-in. timbers prevent any possible shifting in the track at right angles to the length of the trestles. To prevent the ties from creeping, they were attached at intervals by hooked bolts to the small angles inside of the girders. Since the tracks were completed, about two years ago, not a single penny has been spent on them. They are now in as good alignment as when first put in. The height of the trestle is 42 ft. from rail to sollar. The gauge is 30 inches.

The trestle was built under a guarantee to support a movable load of ten tons. It was put into commission during the fall of 1912 and has been used continuously since then. No defects in construction or design have been discovered. No delays in loading with the steam shovel have been occasioned. In the second cut taken by the shovel the track runs fairly close to the piers. The operator, before reaching a point where the pier would prevent his boom from swinging, digs into the pile as far as possible. He then moves the shovel ahead until the front part of it is directly opposite the far edge of the pier. By digging in at right angles to the shovel he is able to get all of the ore in the cut except a small strip on the other side of the pier. The small amount of hand work required for this is hardly worth mentioning. With the wooden trestles there is considerable delay in pulling out legs, consequently ore can be loaded more rapidly from the steel trestle.

At the shaft the ore is dumped during the stocking season into special saddleback cars of about five tons capacity. These cars are operated by the tail-rope system, the power being furnished by two 50-k.w. motors. The cars are of special construction and dump automatically simply by running over a dump-jack placed between the tracks at the desired point on the trestle. This releases the catches and allows the doors to open. By shifting a lever on one end of the car, three grades of ore can be stocked from each track. On top of the plate girders, between the rails, the 5/8-in. rope is carried on wooden rollers. On the end of the trestle it passes around a roller-bearing sheave 2 ft. in diameter. Below the tracks the return rope is supported on small sheaves placed at intervals of about 30 feet. The slack is taken up by four special tighteners which are placed at the end of each track. The tightener consists of a truck, to one end of which is attached a 2-ft. roller-bearing sheave and from the other a rope, which passes over a stationary sheave to a large iron bucket suspended below the trestle. The slack in the rope is controlled by putting the proper weight in the bucket. Placing the tighteners at the end of the line rather than near the winding drums at the shaft house has been found to be a great improvement.

The common method of disposing the rock is to dump it into a special car which runs out on another trestle from a switch from the main line. At the Negaunee mine the rock dump consists of a wooden trestle built at the extreme end of one of the permanent trestles. Rock can be hoisted at any time and disposed of without delay or extra labor simply by throwing a lever on the end of the car and sending it to the rock dump. This method has been found to be very practicable and to save considerable time. Great care was used in laying the tracks on the entire trestle and in giving the curves the proper elevation, the consequence of which is that the cars can be run at a speed as high as 1,400 ft. per minute on the straight part without danger of their leaving the track. The following table shows the cost of the various items connected with the trestle:

COST OF EIGHTEEN PIERS.

	Amount.	Per Yard.
Excavation, 1,800 yards	$ 994.65	$ .553
Concreting, 1,352 yards	5,142 70	3.80
Bolts, washers and forms	2,167.94	2.185
Reenforcing steel	1,423.89	1.053
Total	$9,729.18	$7.197
Average cost per pier	540.41	

STEEL TRESTLE, 2,594 FEET.

	Lin. Ft.	Amount.	Per Ft.
Steel erected		$35,100 00	$13.53
Colums (18)	2,094	9,729.18	4.65
Small piers for curved trestle (20)	500	641.93	1.28
Decking	500	1,870.07	3.74
Ties and fastenings	2,094	1,627.59	.78
Walk and railings	500	358.78	.72
Temporary tracks for unloading	2,594	355.89	.14
Rail and laying	2,594	1,545.48	.60
Total	2,594	$51,228.92	$19.71

From figures obtained from several mines it has been found that in five years the total cost of repairs and renewals on wooden stocking trestles amounts to the original cost of the trestle. Breakage in legs is exceedingly high, often amounting to as much as 33 per cent. per year. If for any reason ore is not shipped and the legs are allowed to remain in the pile for several seasons, it has been observed that they rot rapidly. Weather conditions have considerable to do with the percentage of broken legs. If ore is dumped on a frozen face of the stockpile and this new ore freezse rapidly, it will often move in a mass down on the frozen face and break the legs. Large masses of frozen ore also shift in this way during loading with the steam shovel.

The cost for erecting and dismantling was accurately kept at two large mines for a period of years. It was found to amount to $1.20 per foot. Under unusual conditions this has run as high as $1.60 per foot. The portion of the trestle between the shaft and the point where ore is stocked is usually called the permanent trestle, the other part being the stocking trestle. The permanent trestle is put up in a very substantial way and is expensive, costing as much as $15 per foot. After a period of ten years this permanent trestle is sure to be in bad repair. A few of the stringers not directly below the

STOCKPILE AFTER REMOVAL OF ONE CUT BY SHOVEL

tracks will probably last for a short additional time, but for the sake of an estimate it can be assumed that the permanent trestle will have to be entirely rebuilt in ten years. In making the following comparative statement of the cost of wood and steel, the expenditure each year at 6 per cent. compound interest has been used. This yearly expenditure has been accumulated and figured at compound interest for a period of twenty years. It is found that at 6½ years the costs for wooden and steel trestles of the same length are practically identical. As the time increases the accumulated amount for repairs, renewals, erecting and dismantling, figured at 6 per cent. compound interest, increases very rapidly. At the end of twenty years the saving in favor of the steel stocking trestle is $117,000. It is impossible to estimate the saving due to better tracks and operating conditions and consequently the minimizing of delays on the surface. With a wooden trestle a certain number of carpenters and extra laborers must be employed. Only a part of their time can be charged against the stocking trestle, but it is nevertheless necessary to have them so that they can be used when repairs are needed. At the Negaunee mine we have only one carpenter, whose entire time is spent in the shop.

Comparative Cost of Wood and Steel Stocking Trestles

	6½ Years.	20 Years.
Permanent Wood Trestle—		
Original cost, 500 ft. at $15	$ 7,500.00	$ 7,500.00
Repairs and renewals, 10 per cent. per year	4,875.00	15,000.00
Six per cent. compound interest	4,692.29	30,798.02
Total	$17,067.29	$53,298.02
Temporary Wood Trestles—		
Original cost, 2,094 ft. at $6	$12,564.00	$12,564.00
Repairs and renewals, 20 per cent per year	16,333.20	50,256.00
Erecting and dismantling, $1.20 per foot per year	16,333 20	50,256.00
Six per cent. compound interest	14,063.33	122,822.09
Total	$59,293.73	$235,898.09
Total cost wooden trestles	$76,361.02	$289.196.11
2,594 Foot Steel Stocking Trestle—		
Original cost	$51,228 92	$ 51.228.92
Estimated maintenance cost	1,300.00	4,000.00
Six per cent. compound interest	23,949.51	116,867.78
Total	$76,478.43	$172,096.70
Net saving	117.41	117,099.41

Discussion.

Mr. Abbott: I would like to ask if you have had any trouble in removing the ore in the vicinity of the supporting pillars of the trestle; if it required any hand work or can the steam shovel reach all of the ore conveniently?

Mr. Elliott: Practically no additional labor is necessary.

Mr. W. H. Johnston: Have you experienced any difficulty in the ore freezing around the pillars?

Mr. Elliott: No, we have loaded ore for two seasons and no trouble has been experienced from freezing around the columns. It does not stick to the columns. There is not nearly as much trouble in loading from this trestle as from a wooden trestle. In the latter you always have the delay due to the pulling of trestle legs.

MR. JOHNSTON: You also have the advantage of always being ready to stock the ore. There are times when we have not been ready to stock ore.

MR. KELLY: This method also eliminates the danger to life in drawing trestle legs.

MR. P. S. WILLIAMS: Why did they choose the endless rope system of haulage as against handling the cars with electric motor, for which power can be furnished cheaply. I think myself it is possibly due to increased speed of operation but I would like to hear from Mr. Elliott who has comparative figures on the cost of different systems of stocking ore.

MR. ELLIOTT: I think the use of the motor would be cheaper but, of course, the element of danger to the men riding these motors is very great, and that is one of the principal objections to the use of motors.

MR. KELLY: Probably there would be a little saving in power by the trolley system, but the labor cost might be a little more, because the man at the shaft will run out the endless rope and still be at the shaft where he can answer the bells. In certain cases the trolley system would require additional men. Then, also, the man running out the trolley is exposed to the inclemency of the weather while the man running the endless rope is in a house.

MR. ELLIOTT: I might add that if we used motors the cost of the trestle would have been greatly increased because it would have been necessary to build a much more rigid trestle. The moving load would have been increased six or seven tons, which would have greatly increased the cost of the trestle.

MR. WILLIAMS: I was surprised to hear Mr. Elliott say that he thought the cost would probably be cheaper by motor. From my experience with endless rope haulage, using steam, I would say it is considerably cheaper than electric haulage on a long trestle.

MR. EATON: I would say that the results we have obtained with endless rope haulage using steam and electricity for power, are almost contradictory. We hardly know where we stand. At the Lake Mine in Ishpeming we have a 40-h.p. Corliss engine driving the endless rope on two tracks. When stocking ore 1,700 feet from the shaft, a few years ago, it was necessary to haul the cars in trains of two, and often all four cars would be in motion at the same time, two loaded cars going out and two empties coming in. The steam engine handled this load without much difficulty. In our more recent installations each rope is driven independently by a 50-h.p. electric motor, and this motor has all it can do to handle one car.

MR. STANFORD: I think we all appreciate that a 40-h.p. steam engine, under these conditions is not working at a quarter cut-off, and is probably taking steam the full length of the stroke. My judgment is that the cost is probably less with the endless rope system than with the electric locomotive. I would qualify by saying that it would apply to the top tramming system as used at all of our mines, and I believe that the cost of power is probably less than it would be with the electric locomotive.

VENTILATION IN THE IRON MINES OF THE LAKE SUPERIOR DISTRICT.

BY EDWIN HIGGINS, PITTSBURGH, PA.*

INTRODUCTION.

The purpose of this paper is to set forth the general conditions existing in Lake Superior iron mines with regard to ventilation, more especially those conditions which have an effect upon the health and efficiency of the miner. Some remedies are suggested for the most serious conditions, those which undoubtdly affect the cost of producing ore through their ill effect upon the miner.

It may be well to state here that I am at present engaged, in collaboration with associated mining engineers and chemists, in the investigaton of ventilation in the metal mines of the United States for the Bureau of Mines. The field work for this investigation was started in the Lake Superior district early in 1913. While the notes on that district are approximately complete, it is probable that some further observations will be necessitated in the light of results from experimental work that has been carried on in the Pittsburgh laboratories of the bureau. In the course of the field work in the Lake Superior district visits were made to nearly all the mines in Michigan and Wisconsin, and some of those on the Mesabi and Vermillion ranges in Minnesota.

Although many air samples were taken, their analyses will be made use of only in pointing out general conditions. While it is not the purpose here to detail the results of these investigations, it has been thought that a discussion of the more important phases of the subject might be of interest and value. It is hoped that this paper, which is of a preliminary

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nature, will lead to discussion that will be of value for use in the bulletin on ventilation to be issued by the Bureau of Mines.

General Conditions in the Mines.

All the mines visited, with the exception of two, depended on natural ventilation for the supply of air to the working places. Of the two exceptions, one mine had a blower fan installed underground, and in the other the air was kept in motion by means of compressed air jets. In a few cases booster fans were found in use in dead ends, especially in those immediately under the timber mat. The amount of air entering the mines per man employed underground varied greatly, but in the majority of cases was between 50 to 100 cu. ft. per man per minute.

Quality and Temperature of the Air in the Main Airways. The analyses of many air samples showed that seldom in the main airways did the air contain any appreciable amount of noxious gases. The only exception to this statement might be said to be in reference to the "return" air issuing from the mine after use therein; this showed a minimum of 0.2 per cent. and a maximum of 0.8 per cent. of carbon dioxide. Invariably the heavily timbered mines showed a higher percentage of carbon dioxide in the return air, than did those mines in which little timber is used.

As to temperatures, the fresh down-cast air varied, of course, according to the season of the year. Summer temperatures may be said to range from 50° (nights) to a maximum of 100° F. (days) in the shade; in the winter temperatures range from the vicinity of 0 to a maximum of 30 to 40° F. below. At all times the humidity is comparitively low.

In the deeper mines (1,000 feet or more) the temperature underground showed little variation, no matter what the temperature on the surface. In the shallower mines, however, it is common in winter to encounter huge icicles, in some cases as deep as 300 ft. from the collar of the down-cast shaft. In the heavily timbered mines, the return air ranged in temperature from 75 to 90°, and humidity usually from 95 to 100 per cent. In mines where little timber is used the return air is from 10 to 15° cooler.

Condition In Working Places. The working places near the main air courses, both in mines using little timber, and in those using a great amount of timber, were found to present no abnormal conditions. However, in the dead ends, such as are encountered in driving long cross-cuts or drifts, or in sub-levels immediately under the timber mat, severe conditions were noted in many cases. In the heavily timbered mines temperatures in such working places were found to range from 75 to 100° (humidity from 95 to 100 per cent). Many air samples taken from such places showed from 0.5 to as high as 3 per cent. carbon dioxide. It was found that the gases produced by blasting gave a great deal of trouble. The expedient of turning on the compressed air after blasting was not always effective.

Gases Found in the Mines and Their Effect Upon the Human System.

Atmospheric air may be considered as consisting of approximately 20.93 per cent. oxygen, 79.04 per cent. nitrogen, and 0.03 per cent. carbon dioxide.

Gases Produced Under Ordinary Operating Conditions. With the exception of the combustible hydro-carbon gases reported from time to time from some of the mines situated in the carbonaceous black slate area of the Menominee range, the only noxious gas that is encountered under ordinary operating conditions is carbon dioxide. No explosive gases occur. Reference is made further on to gases produced after blasting.

In mines, carbon dioxide (CO_2) is produced by the breathing of men or animals, the combustion of timber and explosives, the burning of lamps, and the decay of timber or other vegetable matter. It is a colorless gas, without odor, and has a slightly acid taste. Its specific gravity (air equals 1) is 1.529 at ordinary temperatures. Carbon dioxide, in the quantities in which it is ordinarily found in mines, does not directly poison the person or animal breathing it. When it is present in the air of mines there is usually a deficiency of oxygen. The first effect of breathing air containing 2 to 3 per cent. carbon dioxide, is headache and dizziness; larger percentages cause extreme panting. When the human being breathes air containing about 10 per cent. of carbon dioxide life becomes imperiled. Candles in air are usually extinguished when the oxygen content decreases to 16 or 17 per cent. Carbon dioxide that may be present has but slight effect upon the extinguishment. Carbide lamps become extinguished when the oxygen decreases to about 12 per cent.

Gases Produced By Blasting. In addition to carbon dioxide there are produced by the combustion of explosives, depending on the kind used, varying percentages of hydrogen, methane, oxides of nitrogen, carbon monoxide, water vapour and hydrogen sulphide. For the purpose of this paper it will suffice to say that very small percentages of either carbon monoxide, oxides of nitrogen or hydrogen sulphide have marked effects upon the human system. One tenth of one per cent. of any of these gases have a serious effect upon the miner. Experiments by the Bureau of Mines indicate that the oxides of nitrogen and hydrogen sulphide are even more dangerous, in the same quantity, than carbon monoxide.

Gases Produced During Mine Fires. During timber fires in metal mines the noxious gases produced are carbon dioxide and carbon monoxide; the effect of the former has been discussed above. Carbon monoxide (CO) is far more deadly than carbon dioxide in its poisonous effect on the system. It is a product of incomplete combustion of wood or other combustible matter, also of the explosion of various types of blasting powder or dynamite. The amount produced is enormously increased when the explosive burns instead of detonating. Carbon monoxide is more than likely to be encountered during a smouldering fire, such as would result in a damp or wet mine. It is a colorless gas and has a specific gravity of 0.967. As little as 0.2 per cent. of this gas will cause death if breathed for a sufficient length of time. It acts as a cumulative poison to the human system by combining with the haemoglobin of the blood, thus preventing that agent from combining with sufficient oxygen to support life. It gives little or no warning of its effect on the system. The person breathing it usually becomes suddenly weak in the knees and lapses into unconsciousness. Carbon monoxide may occur in quantities sufficient to cause sudden death, and still its presence will not be indicated by the dimming of the candle flame. Thus it may be seen that the belief of many miners that they can live wherever a candle will burn, is erroneous.

For more detailed information regarding certain of the gases mentioned above, the reader is referred to Bureau of Mines technical paper 62: "Relative Effects of Carbon Monoxide on Small Animals" by Messrs. Burrell, Seibert and

Robertson; and miner's circular 14: "Gases Found In Coal Mines," by Messrs. Burrell and Seibert.

Effect of High Temperatures and Humidity.

By the efficiency of the miner is meant his capacity to perform work. That high temperatures and extreme humidity have a marked effect in lessening the efficiency of the miner, there can be no doubt. In this connection Haldane[a] says "The normal body temperature of a man is from 98 to 101° F., and in order to obtain efficiency in work, his temperature should not exceed this upper limit. The body may be cooled by radiation, conduction and evaporation (sweating.) Cooling by evaporation is the most important in deep mine ventilation. Evaporation from the body can only occur when the dew point of the surrounding air is below body temperature, 98° F. * * * In order to maintain the body temperature in hot mines, where one is working, it is necessary to keep the skin at a lower temperature than the interior of the body. The body temperature may be maintained when 78° F. wet bulb in still air, and 88° F. wet bulb in good moving air, is shown * * * *"

According to G. J. Young [b]: "With a temperature from 95 to 105° F., and relative humidity 50 to 70 per cent. in still air, miners can do efficient work. From 110 to 115° F., and with other conditions the same as above, efficient work cannot be done. Increasing the velocity of the air, with other conditions the same as above, makes work more bearable, but miners cannot work very long at a time under such conditions. 95 to 105° F., in saturated air and no velocity, is dangerous; 90 to 98° F., saturated, velocity of air current 400 to 500 ft. per minute, and slightly vitiated, will prevent efficient labor. Impurities in the mine air seem to hinder labor efficiency more than high temperatures do. The humidity of the air depends upon the amount of water in the mine and the dryness of the down-cast air."

High temperatures in a comparatively dry air do not have so great an effect on the miner. This fact was forcefully illustrated to me on a recent trip through the Comstock mines in Nevada. In one place the dry bulb thermometer read 110° F., and the wet bulb 100°. This represents a humidity of 70 per cent. While performing no work the

a J. S. Haldane, Jour. Chem. Met. & Min. Soc. South Africa, Vol. 11, 1910, page 227.
b Jour. Chem. & Min. Soc. South Africa, Vol. 11, 1910, page 411.

place was not unbearably hot. Nearby, where the return air current was encountered, the wet and dry bulbs both read 110° (representing a humidity of 100 per cent.) and the effect was distressing.

By frequent observations in many of the Lake Superior iron mines, I have noted repeatedly that miners working in temperatures above 75° wet bulb (relative humidity 100 per cent.) showed a marked falling off in energy. At wet bulb temperatures of from 80 to 90° (relative humidity 90 to 100 per cent.) the average miner works only from one-half to one-third of his time; when he is at work under these conditions his efficiency is not normal, and when he is resting, of course, his time is entirely lost. In one mine 4 miners produced the same tonnage of ore as was produced by 9 miners in a similar place in the same mine where the temperature was 10° hotter. Many cases of this kind could be cited.

RELATION OF THESE CONDITIONS TO THE COST OF MINING.

Many notes were made on the relative efficiency of miners working under normal conditions as compared with those working under severe conditions as to temperatures and quality of air. The following example, in which nominal figures are used, will serve to illustrate the effect of poor ventilation on the cost of mining.

A well ventilated mine produces 1,000 tons of ore per day, at a cost of $1,000. The labor cost for this tonnage approximates $750. Now, if the places from which 300 tons of the production comes are poorly ventilated and hot (say 85 to 90°, relative humidity 95 to 100 per cent.) the miners will put in only one-half of their time in effective work. Thus they would produce only 150 tons, instead of 300, as under normal conditions; and the result would be that there would be produced 850 tons at a labor cost of $750, as compared with 1,000 tons at a labor cost of $750 under normal conditions. This would represent an increase from 75c per ton, under normal conditions, to 88c per ton in a poorly ventilated mine—an increase of 13c per ton.

Even if the cost of mining were increased 5c per ton by a preventable cause it would occasion considerable concern to the management. Thousands of dollars are spent in operating equipment in order that a few cents may be saved in the cost of mining a ton of ore. The great importance of proper ventilation has been recognized by some, and efforts are now being made to improve conditions in this respect. Good results have already been obtained in one or two cases. The management of one mine, where production per man has been increased greatly recently, attributes the increase in a great measure to better ventilation facilities.

Causes of Vitiated Air In the Mines.

Oxygen is consumed, and carbon dioxide produced in the mines, through the following agencies:

Oxidation or rotting of timbers.

Breathing of men.

Burning of various types of miners' lights.

Blasting.

Oxidation of certain rocks.

Without going into a detailed discussion, it may be stated that investigation points to the oxidation or rotting of timbers (in the heavily timbered mines) as the chief cause of the vitiation of air. The breathing of men and the burning of candles and lamps come next in importance. In heavily timbered mines (especially where the mine is wet or damp) the timbers consume from three to four times as much oxygen as do all the other factors combined.

Recognizing the importance of this phase of the problem, an investigation was instituted at the Pittsburgh laboratories of the Bureau of Mines. While the work done to date has been only preliminary, some interesting facts have been brought out. The investigation is being carried on by G. A. Burrell, chemist of the bureau, who writes as follows:

The Absorption of Oxygen and Production of Carbon Dioxide from Atmospheric Air by Wood.

"Herein are shown the results of some preliminary experiments having to do with the absorption of oxygen and production of carbon dioxide from atmospheric air by wood. Dried and seasoned pieces of wood planks were sawed sufficiently to produce sawdust. In one case very thin shavings were used. This material was placed in bottles having a capacity of 2½ liters and the bottles securely closed. Through each bottle stopper a glass tube was placed, provided with a stopcock, to permit of drawing out samples of air for analysis.

Experiments to Determine the Effect of Wood in Changing the Composition of Atmospheric Air.

Kind of wood and Wt. in grams		1st Anal. of residual air in per cent Date, 6-27-13	2nd Anal. per cent Date, 7-15-13	3rd Anal. per cent [a] Date, 7-31-13	4th Anal. per cent Date, 8-21-13	5th Anal. per cent Date, 9-16-13	6th Anal. per cent Date, 12-9-13
Ash sawdust	CO_2	.0	.15	3.38	11.6	18.9	20.6
112.5 grams..	O_2	20.8	20.8	17.5	8 6	1.7	.0
Cypress shavings	CO_2	.0	.15	1.98	4 0	6.0	10.
76 grams..	O_2	20.9	20.8	18.75	16 7	14.4	10.1
Hemlock sawdust	CO_2	.2	.20	7.87	16.6	18 0	17.7
135.5 grams..	O_2	20.8	20.8	12 0	2.0	.7	.3
Oak sawdust	CO_2	.2	.2	8.27	17.0	19 2	20.2
136. grams..	O_2	20.7	20.8	15.05	3 1	1.2	.4

(a) Water was added to each bottle 15 days after (7/16/13) prior to these analyses. Enough water was added to saturate the wood so that it caked.

Discussion of Results. The experiments were started on June 6, 1913, and the first analysis of the residual air in the bottles made on June 27, 1913. No appreciable change in the oxygen or carbon dioxide content of the residual air over the composition of ordinary atmospheric air was noticed. The same held true of results obtained on July 15, 1913, or 39 days after starting the experiment. Water was then added to each bottle in quantity sufficient to perceptibly moisten the sawdust and shavings. In 16 days from the time the wood was moistened analyses were made again of the residual air in each bottle. A marked increase in carbon dioxide and decrease in oxygen resulted, and continued until in the case of the sawdust samples it had all or practically all disappeared. In the case of the fine cypress shavings the rate of absorption of oxygen was slower, probably due to the fact that the cypress wood was not in as fine a state of division as the other woods tried. An interesting feature of the results is that the carbon dioxide is only slightly less than the molecular equivalent of the oxygen consumed. This is a different result than that obtained when oxygen is absorbed by coal at ordinary temperatures. In the case of coal the amount of carbon dioxide produced is invariably less than the molecular equivalent of the consumed oxygen. Laboratory experiments by many have shown this. The writer has also observed it many times in the case of samples collected in coal mines. In the case of coal and air, the oxygen may entirely or almost entirely disappear and there result in the residual air only two or three per cent. of carbon dioxide.

"The change in air after contact with coal may be the result of the slow oxidation of the carbon, with the formation of a small amount of carbon dioxide; the oxidation of certain unknown and unsaturated bodies in the coal without the formation of carbon dioxide and possibly also the absorption of the oxygen, and presumably of some nitrogen. That carbon dioxide also disappears after contact with coal has been determined by experiment. Bacterial action apparently does not enter into the case. On the other hand the disappearance of oxygen and formation of carbon dioxide in the case of wood and air is probably almost entirely due to bacterial action. Sometimes small quantities of other gases are formed, methane and hydrogen for instance. The samples examined for this report were not tested for gases other than carbon dioxide and oxygen.

"These results show that timber in metal mines (where large quantities of it are used) may be responsible for part of the vitiation of the air therein, especially in dead ends where the air is stagnant, the wood moist, and much timber is present.

"The results, however, are only preliminary and not quantitative; hence give one no idea of the exact part played in the vitiation of the air of metal mines by the timber. The state of division of the wood is undoubtedly very important. Further experimenting is required to determine the action between air and timbers. The rock in some metal mines, especially if iron pyrites is present, is probably responsible for some of the oxygen disappearance.

"Many of the samples of mine air collected by the bureau, however, have shown a quantity of carbon dioxide almost proportional to the oxygen disappearance, suggesting that the timbers or some reaction that is analogous to that taking place between air and wood is responsible for the vitiation of the air."

Causes of Heat and Humidity In the Mines.

In general, it may be said that heat is developed in mines through the following agencies:

Rock temperatures.

Presence of men and lights.

Crushing and working of rock and timbers, and possibly the oxidation of timbers.

Operation of machinery and presence of steam lines connected thereto.

The cause of humidity, of course, is the absorption of moisture in the mine by the comparatively dry air admitted from outside. In practically every case in the Lake Superior district the air issuing from mines was found to range between 95 and 100 per cent. in humidity.

It was found that rock temperatures had practically no bearing on the great heat encountered in the sub-levels, especially those subs directly under the timber mat. In several cases rock temperatures, at depths of 1,500 to 2,000 ft. were as much as 10° lower than air temperatures from 500 to 1,000 ft. nearer the surface (under the timber mat.) Air currents passing through timbered workings where no men were employed were tested at various intervals, and the temperatures were found to increase gradually, regardless of whether the course of the air was downward or upward. With respect to working places, then, the causes mentioned may be disposed of as of small importance in causing a rise in temperature, with the exception of the crushing and working of the rock and timbers, and the oxidation of the latter. While the laboratory investigations have not progressed far enough as yet to make a positive statement in this connection, it is my opinion, from observations made in the field, that in these mines the oxidation of the timber is the chief cause of the production of heat. In one mine a new sub-level was opened under the sub directly beneath the timber mat. Before the introduction of timber in this new sub, the temperature averaged 75°; when drift sets had been put in the average temperature of the level was 80°.

The Problem.

There are two problems presented in the proper ventilation of Lake Superior iron mines.

1. The supply of a sufficient quantity of air, and its

proper distribution, so that it will carry off the noxious gases produced; and have the effect of lowering the temperature and humidity existing in working places.

2. The production of lesser quantities of noxious gases.

As to the amount of air required in the mines it might be well to cite the requirements of coal mines in this country. In non-gaseous mines the average requirement is 100 cu. ft. of air per minute per man employed underground and 500 cu. ft. per minute per animal. In gaseous mines these figures are increased. On an average, perhaps 50 per cent. of this air reaches the working faces, the balance being lost by leakage through stoppings and doors.

The conditions in the iron mines differ greatly from those in coal mines. As indicated on previous pages, the most important considerations are the oxygen consumed, and carbon dioxide produced, by the oxidation or rotting of timbers, and by the breathing of men and the burning of lights. In the iron mines the employment of animals exists only in occasional cases.

It is a difficult matter to state just how much air should be supplied in the heavily timbered mines for the reason that there is no accurate method of calculating how much oxygen the timbers will consume. The factors effecting this are extremely variable. Damp timbers are much more active in oxygen consumption than are dry timbers. Again, due to the methods of mining, it is impossible to figure with any degree of accuracy the amount of timber in a mine. However, a study of actual conditions lead me to the belief that, in untimbered mines, where no animals are used, 50 cu. ft. per minute per man employed underground, is sufficient air. In mines where a moderate amount of timber is used there should be 100 cu. ft. per minute per man employed underground. In the heavily timbered mines, it may be necessary to increase the amount to 150 or even 200 feet per minute, depending upon the amount of timber in the mine.

There are several guides in determining whether or not there is a sufficient amount of air entering the mine. In the first place there should be sufficient air to prevent the humidity in working places from rising higher than 90 per cent. With 90 per cent. humidity the wet bulb thermometer should not read more than 80° in still air, and 85° in a current of 400 to 500 ft. per minute; with 100 per cent. humidity these figures may be set at 75 and 80°.

The second consideration is the diminution of the amount of oxygen in the air. As pointed out, this is closely related, in the Lake Superior iron mines, to the amount of carbon dioxide in the air. In England, ventilation requirements deal with the oxygen and the amount of carbon dioxide in the air. The requirements, (not less than 19 per cent. oxygen, or more than 1.25 per cent. carbon dioxide), refer to coal mining, in which the ratio between the oxygen and carbon dioxide contained in the air is not as constant as it is in metal mines.

Distress may be caused by breathing in atmosphere containing too little oxygen, or too much carbon dioxide. Haldane, in a report on "The Causes of Death in Colliery Explosions and Underground Fires," writes as follows:

"A diminution from 20.93 to 15 per cent. oxygen by volume is practically without effect on man, although, of course, a candle or wick-fed flame is instantly extinguished. As the decrease of oxygen proceeds further certain effects begin to be noticed, but a person not exerting himself will, as a rule, not notice anything unusual until the oxygen percentage has fallen to about 10 per cent. The breathing then becomes deeper and more frequent, the pulse more frequent, and the face somewhat dusky. From this to lower percentage the symptoms are more pronounced, and a person's life becomes in grave peril."

Haldane's experiments refer to fresh air. Experiments by the Bureau of Mines support these statements.

Haldane also states that carbon dioxide in air produces no very noticeable effect on man until the proportion of carbon dioxide reaches about 3 per cent. When the proportion is increased to 5 or 6 per cent. there is distinct panting, throbbing, and flushing of the face.

In exploring a certain mine after an explosion engineers of the Bureau of Mines suddenly entered a mine atmosphere containing 13 per cent. of oxygen and 4 per cent. of carbon dioxide. They experienced no distress, but they were in the atmosphere only a few minutes.

While a miner may feel no discomfort while not exerting himself, in an atmosphere in which a candle will become extinguished (from 16 to 17 per cent. oxygen), the effect may be very different when carbon dioxide is present and he is working hard. Another factor to be considered is the heat usually encountered in places containing vitiated air. I have noted miners, when working, showing ill effects in an atmosphere containing 1 per cent. carbon dioxide and 19.7 per cent. oxygen, the temperature being 75° and the relative humidity 95 per cent. It is my belief that miners will begin to lose efficiency in air containing more than 1.25 per cent. carbon dioxide and less than 19 per cent. oxygen, in ordinarily cool temperatures; when the working place is hot the effect is correspondingly worse.

Recommendations for the Rand mines by S. Perlerich (a) are: That sufficient air shall be provided so that in one hour after a shot is fired, a sample taken anywhere in the mine will not contain more than 0.2 per cent. carbon dioxide, and 0.01 per cent. carbon monoxide, and only traces of the oxides of nitrogen.

It is a simple matter to determine whether conditions in working places are such that miners can perform efficient work. Temperatures and humidity may be determined by the use of the sling psychrometer; gases present may be determined by sampling and analyzing the air.

REMEDIAL MEASURES.

The principal remedy for the conditions referred to is a sufficient air supply, and its proper distribution throughout the mine. Increased air supply may be effected; (a) by providing a greater number of openings to the mine; (b) providing for down-cast and up-cast openings, with due regard to the elevation of the shaft collars, and the presence or absence of steam pipes in the shaft; (c) by the use of fans either at the shaft collar or within the mine. A blower fan at the collar of the down-cast shaft is preferable. If an air shaft is not available, that is, one that is not used for hoisting, it may be possible to utilize the manway in an operating shaft as an airway, but in this case the partition between the manway and the hoisting compartments must be absolutely tight. If it is not practicable to place the fan at the shaft collar, it must then be placed within the mine workings, preferably a blower fan somewhere near the down-cast shaft.

Many of the mines have a sufficient amount of air passing into them but, owing to insufficient airways, most of the air escapes from the mine without reaching the working places. Such conditions can be remedied by the running of additional

a Jour. Chem. Met. & Min. Soc. of South Africa, Vol. 11, 1910, p. 59.

crosscuts, drifts and raises for carrying the air, and by the installation, at proper places, of doors and brattices. An important aid in ventilating dead ends may be found in the intelligent use of electrically operated booster fans.

With regard to measures looking to a reduction in the noxious gas produced in the mine, those worthy of consideration are: (a) The treatment of timber with such preservatives as will prevent or retard oxidation or rotting, and (b) the use of explosives that produce a minimum amount of noxious gases. The treatment of timber has been discussed in various papers and publications and it is probable that the use of some preservative that will act as a sterilizing agent will be effective in the Lake Superior mines.* Probably the preservative most used at this time is creosote. However, this is a subject that requires further investigation before definite recommendations can be made. The cost of treatment is an important factor. It might be added that stripping the bark from timber retards, to some extent, its liability to oxidation.

REDUCTION OF NOXIOUS GASES FROM EXPLOSIVES.

On account of the many reports received of the serious effect of powder gases on miners (a surprising number have been overcome and not a few have died), the Bureau of Mines recently undertook an investigation with the hope of developing a powder which would evolve, on detonation, a minimum quantity of noxious gases.

As the result of a number of tests with straight nitroglycerin, low freezing, ammonia, and gelatin dynamites, the fact was brought out that the gelatin dynamites evolve smaller quantities of noxious gases than any other. There is given, herewith, a table showing the compositions of gelatin dynamites of various strengths. Table II shows the combustion products resulting from tests of explosives in thin paraffin paper wrappers.

Several samples of 40 per cent. gelatin dynamites were procured from different manufacturers; of these samples the whole produced poisonous gases on detonation. The percentage of carbon monoxide varied from 3 to 5.7 per cent. and of hydrogen sulphide from 0.7 to 4.1 per cent. As a final result of the investigations a 40 per cent. strength gelatin dynamite was prepared according to the following formula:

*"Wood preservation with especial reference to Mine Timbers." John M. Nelson, Jr. Vol. XIV. pp. 99-115.

Special formula for 40 per cent. strength gelatin dynamite.

Nitroglycerin	33
Nitrocellulose	1
Sodium nitrate	54
Combustible material (a)	11
Calcium carbonate	1
	100

(a) Flour.

The products of combustion were collected in a Bichel gauge. This is described in Bureau of Mines Bulletin 15, page 103.

The results of tests made with this explosive are shown in table III.

TABLE I—COMPOSITION OF GELATINE DYNAMITES OF VARIOUS STRENGTHS.

Ingredients	30 per cent strength	35 per cent strength	40 per cent strength	50 per cent strength	55 per cent strength	60 per cent strength	70 per cent strength
Nitroglycerin	23.0	28.0	33.0	42.0	46.0	50.0	60.0
Nitrocellulose	0.7	0.9	1.0	1.5	1.7	1.9	2.4
Sodium nitrate	62.3	58.1	52.0	45.5	42.0	38.1	29.6
aCombustible material	13.0	12.0	13.0	10.0	9.0	9.0	7.0
Calcium carbonate	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

a Wood pulp is used in 60 and 70 per cent strength gelatin dynamite Sulphur, flour, wood pulp, and sometimes resin are used in other grades. Some manufacturers replace a small percentage of the nitro-glycerin in these grades with an equal amount of ammonium nitrate. This replacement, however, offers little, if any, advantage other than reducing the cost of manufacture.

TABLE II—COMBUSTION PRODUCTS RESULTING FROM TESTS OF EXPLOSIVES IN THIN PARAFFINED PAPER WRAPPERS.[a]

(A. L. Hyde, Analyst.)

Class and grade of explosive	Electric detonator used. No.—	Weight of products or combustion (grams)			Gaseous products (per cent by volume)							Solids (per cent)		Volume of gas (liters)
		Gaseous	Solid	Liquid	Carbon dioxide	Carbon Monoxide	Oxygen	Hydrogen	Methane	Nitrogen	Hydrogen sulphide	Soluble	Insoluble	
30 per cent "straight" nitroglycerin dynamite....	6	96.8	102.1	12.9	22 9	28.4	0.0	20.6	0.7	27.4	...	88.00	12.00	85.8
40 per cent "straight" nitroglycerin dynamite....	6	107.4	87.1	12.4	27.3	26.9	.0	18.0	.4	27.4	...	86.73	13.27	88.5
40 per cent "straight" nitroglycerin dynamite....	6	124.6	70.3	14.7	24 4	31.2	.0	20.7	.7	23.0	...	79.14	20.86	105.5
60 per cent "straight" nitroglycerin dynamite....	6	143.5	49.6	11.9	22.2	34.6	.0	23.2	.8	19.2	...	68.53	31.47	128.9
60 per cent strength low-freezing dynamite.......	6	161.5	43.5	3.9	8 9	47.4	.0	31.0	.6	12.1	...	78.76	21.24	169.5
40 per cent strength ammonia dynamite..........	6	95.7	85.9	26.1	41.4	3.8	.0	3.1	.8	45.5	5.4	86.03	13.97	65.6
40 per cent strength gelatin dynamite............	6	96.3	96.3	11.7	50.8	3.0	.0	1.8	.8	39.5	4.1	87.32	12.68	60.3
5 per cent granulated nitroglycerin powder [b].....	6	115.5	93.6	8.3	51.3	2.7	.0	.9	.7	28.7	15.7	78.00	22.00	61.6
FFF black blasting powder [c]....................		154.4	126.9	4.1	49.7	10.8	.0	1.8	.6	28.4	8.7	91.20	8.80	67.8

[a] The explosives named in this table are not of the same formulas as those in the tables on pages 8 and 9.

[b] Primer of 40 per cent "straight" nitroglycerin dynamite, representing 10 per cent by weight of the charge, was used, but the gases evolved by the dynamite were deducted in the computations of the volume of gas (liters).

[c] Black powder igniter used.

TABLE III—COMBUSTION PRODUCTS RESULTING FROM TESTS OF SPECIAL 40 PER CENT. STRENGTH GELATIN DYNAMITE.

(Analyst A. L. Hyde.)

Weight of Products, Grams.	
Gaseous	85.5
Solids	102.3
Liquid	13.2
Gaseous Products, Per Cent. by Volume.	
Carbon dioxide	51.0
Carbon monoxide	.0
Oxygen	.9
Hydrogen	.0
Methane	.7
Nitrogen	47.4
Hydrogen sulphide	.0
	100.0
Solids, Per Cent.	
Soluble	92.10
Insoluble	7.90
	100.00

In order to determine whether these results could be checked in actual mine operation, tests were made in two different mines and the results were practically the same.

The above investigations are described in detail in Bulletin 48, Bureau of Mines, "The Selection of Explosives Used in Engineering and Mining Operations" by Clarence Hall and Spencer P. Howell. The following statement regarding the work is of interest:

"The mine tests, although of small scope, confirmed, with a few exceptions, the tests made in the pressure gauge. The odor of hydrogen sulphide was noticeable immediately after firing some of the explosives containing sulphur, but the chemical analyses of the mine-air samples failed to disclose the presence of an appreciable quantity of this gas. Several days intervened between the taking of the samples in the mine and the chemical examinations made of them, and it is possible that if minute quantities of hydrogen sulphide were collected in any of the samples, they were decomposed by standing so long. It is worthy of note that in all the tests the explosives were completely detonated and there was no formation of nitrogen oxides.

"The results of the experiments indicate that all gelatin dynamites should be made with an oxygen excess sufficient to completely oxidize all combustible materials present, including the wrappers; furthermore, the tests show that when this class of explosive is properly and completely detonated the proportion of harmful gases evolved is reduced to a minimum. However, it should be remembered that proper conditions do not exist if there has been any chemical or physical change in the explosive or if it is fired under conditions that cause burning or incomplete detonation. When the explosive has aged to such an extent as to materially decrease its sensitiveness, when weak detonators are used, or when the explosive is used in a frozen or partly frozen condition, a greater quantity of poisonous gases is evolved."

CONCLUSIONS.

It is hoped that the foregoing discussion will impress mine operators with the importance of the subject of mine ventilation, both as to its effect upon the health of the miner, and as to its relation to the cost of mining. It is further hoped that the remedial measures suggested will have the result of instituting attempts looking to the improvement of ventilation in the mines. The result of such attempts will be of great value in the ultimate solution of this important problem. While the problem is not serious in the mines using little timber, it is one of great moment in heavily timbered mines; and it will increase in seriousness as the mines of the district reach greater depth.

MR. HIGGINS: I wish to bring out one point and that is the chief purpose of this paper, which is to indicate the effect of poor ventilation on the efficiency of the miner and to show how this may seriously affect the cost of mining. I think that if some one would come to the operator of a large mine in the Lake Superior district and say, "I can install a machine or machines that will decrease your cost of mining five cents a ton" that a great deal of attention would be given to the matter. It is probable that if the machine proved its worth that many thousands of dollars would be spent on its installation. I maintain that many of the operators are overlooking an important factor in the cost of mining, and that the cost of mining is seriously affected by poor ventilation.

In my paper I have submitted an illustration, using nominal figures, which show that under ordinarily serious conditions the cost of mining may be increased 13 cents per ton. I would like to go over this illustration. Suppose a mine produces 1,000 tons of ore per day and the cost of mining this ore is $1,000. The labor cost is approximately $750. Suppose the places from which 300 tons of the ore comes are hot and the air is slightly vitiated, containing say from .5 to 1 per cent of carbon dioxide; suppose the temperature in these places is from 80 to 90 degrees and the humidity 100 per cent. The men would work about half time effectively and would produce from this place 150 tons of ore instead of 300. In other words, there would be produced in the mine 850 tons of ore at a labor cost of $750, instead of 1,000 at a labor cost of $750 as under normal conditions. This would represent an increase of 13 cents per ton in the labor cost.

In arriving at the approximate efficiency of miners working under bad conditions as to ventilation, I have given due regard to the opinions of the foremost scientists of this and other countries. Furthermore, I have checked these opinions by actual observation in 75 or 80 mines in the Lake Superior district. There is abundant proof that extreme conditions seriously affect the capacity of the miner to do effective work. In the Comstock mines, reported to be the hottest in the world, I found miners working from 1/5 to 1/6 of their time and receiving therefor a day's pay. However, conditions in the Lake Superior district are not nearly as bad as that.

I think that investigation wiil point out to many of the operators in the Lake Superior district that conditions are as bad, if not worse, than those used in the above illustration. I have a statement from a gentleman who has charge of the ventilation of a large iron mine in the Lake Superior district that four men produced more ore from a certain working place than did nine men in a similar working place where the temperature was ten degrees higher and the air slightly vitiated. I think there are a great many cases of this kind. Doubtless the time is coming when this subject will receive a great deal of attention. As a matter of fact several companies have already given attention to ventilation in their mines. Conditions will get worse as the mines grow deeper. I desire to impress upon the operators of the Lake Superior district the importance of proper ventilation from the standpoint of the health and efficiency of the miner.

Discussion.

Mr. McNair: In this paper, Mr. Higgins speaks of the vitiation of the air due to the production of carbon dioxide in heavily timbered mines and suggests that something may be done to lessen that production. I would like to ask him if he has any specific suggestion; if he has observed any mine in which any process is applied to timber before it is put in place which has been successful in arresting the production of carbon dioxide.

Mr. Higgins: I might say that this phase of the subject is not treated in my paper. We hope that the suggestions made may produce some experimental work along these lines. Various preservatives are used on timbers but we have not as yet any comparative results. I think the most commonly used preservative today is creosote. In investigations up to this date, where the air passed through timber which had been creosoted, the production of carbon dioxide was very slight. Experiments leading up to that point are being carried on now. At the Pittsburgh station, sawdust was placed in a bottle and in the course of two or three months it had consumed every particle of oxygen and converted it into carbon dioxide.

Mr. McNair: I might ask Mr. Higgins if he has any data or any opinion to offer as to whether the application of preservatives to underground timber might sufficiently prevent the rotting process and so prolong the life of the timber in certain places as to offer some return to the mining companies for expense incurred.

Mr. Higgins: I do not think there is any question but that the consumption of oxygen by wood or other carbonaceous matter is a process of rotting, and that the treatment of these timbers with some preservative that will prevent their oxidation would naturally prevent the rotting. That is generally accepted. I hope to prove before we get very far with this investigation not only that rotting is responsible for the vitiation of the air and the production of carbon dioxide, but that it is also responsible for the production of heat.

Mr. Williams of Urbana, Ills: I would like to make a remark in reply to the professor's question. There is a coal mine near Peoria, in Illinois, where they had a great deal of trouble with the timber. Eighteen months to two years was all the life they could get out of timbers. They tried a preservative and that timber has now been in six years. The cost of untreated timber was 10 cents per running foot, of treated timber 17 cents. About eight months ago I tried to hang a hydrometer on one of these timbers. The foreman asked me whether I was a good carpenter. I knew that the timber had been treated and was consequently prepared to strike light blows and it was about a five minutes job for me to get a nail into that timber. It was just as sound and hard and strong as the day it was put in. It not only is strong after being treated but apparently gets stronger with age. How long that strength will continue to increase has not been demonstrated. This is a case of about six years against eighteen months to two years. The preservative was creosote. Oak does not show the same increase as some of the more porous woods that will allow the creosote to enter the pores. White oak is too short grained.

MR. EATON: In answer to Mr. McNair's question I would say that the mines where we have trouble in ventilation are those where the ground is very heavy, where the timber crushes before it has a chance to rot. When timber will stand up only two or three weeks the use of a preservative would not be of much benefit. As to whether or not a preservative applied to the timber would prevent the formation of carbon dioxide after the timber had been crushed and had gone into the "mat" or "gob," there is some doubt. In the Cripple Creek District in Colorado there was, in a great many mines, trouble caused by carbon dioxide entering the workings from fissures, and this trouble was overcome by maintaining in the workings a pressure slightly higher than that of outside air, thus driving the carbon dioxide back into the fissures.

I would like to ask Mr. Higgins his opinion in regard to the applicability of this pressure system of ventilation to our mines. Mr. Higgins, do you not think that an air pressure of, say, three inches of water in our mines would keep the carbon dioxide back in the old timbers and prevent it from entering the workings where the men are now employed? Do you not think that by keeping this carbon dioxide back in the old timber further oxidation would also be reduced, if not prevented? It will be very interesting to hear your opinion on this subject.

MR. HIGGINS: Six months ago I had occasion to visit some of the Cripple Creek mines in which carbon dioxide is given off by the country rock. I took samples of the air and investigated the pressure system of ventilation. I began to think of the Lake Superior District and wondered if the pressure system used on the sub-levels might not have the effect of improving conditions, while I believe that the pressure system would hold the gases back, it is doubtful if it would decrease the heat. I do not see how it could. In some of the mines heat is the greatest trouble. In one mine I found miners working in a temperature of 65 degrees (100 per cent. humidity) and stripped to the waist on account of vitiated air. Under conditions like that I think it would be very good. I talked that over with one of your men and suggested that I would like to see this system tried under such conditions.

MR. SPERR: The greatest difficulty arising from the vitiation of the air by decaying timber, is in the stopes where the timber is required to last but a very short time. The decay does not set in until after the timber has served its purpose of sustaining a temporary opening. A great quantity of timber accumulates in a mat following the stope downward. The slow combustion of this mat makes the troublesome heat in the working places. This applies particularly to the method of mining to which Mr. Channing refers in his paper under the head of "The Caving System of Mining." (In this issue.) This system of mining by successive timbered slices worked from the top of the ore downward, has undergone many modifications since it was introduced with the top slicing method about thirty years ago. First the slices were mined and timbered in immediate contact with each other; then between the slices about five feet of ore was left to be caved; then the distance between slices in different instances, was increased more or less until 100 feet has been successfully attained in what is known as the "Block Caving Method." In order to avoid the excessive use of timber with its consequent heat and bad ventilation, I believe the tendency with the attainment of greater depth in the mines will be more and more to get away from the top slicing, and to approach the block caving method, by which the ventilation can be greatly improved, and the shoveling and tramming in the stopes can be largely eliminated.

In all early mining operations, when the mines are shallow, the attempt has been made to give permanent support to the excavations. As greater depth is attained, the excavations are either filled or are allowed to fill themselves by the process of caving, excepting the hoisting and haulage ways. The utmost attempt is made to give rigid support to the shafts and drifts, which also fails with only a little greater depth. Concrete and steel supports have been and, no doubt, will be tried. These all fail at certain depth or when rock movement sets in; and they are most troublesome when they do fail. The principle of yielding supports should be employed at and below certain depths in mining operations.

Mr. P. S. Williams: We must have some men here who have had experience in the use of concrete in mines. We have a problem ourselves where a shaft is to go through about one hundred feet of dyke rock at a depth of about two thousand feet. I had in mind putting in reinforced concrete to keep the air away from the rock. My own opinion is that the air disintegrates the rock and if we can keep the air away we accomplish the desired result.

Mr. Sperr: You would for a short time. I would say that as a general proposition in the iron mines, the use of concrete as a rigid support at a depth of two thousand feet would be a mistake for the purpose as mentioned by Mr. Williams. For the specific purpose of keeping the air away from a rock which readily disintegrates, it would serve temporarily; but as soon as pressure develops and any movement sets in, the concrete is absolutely worthless and steel is a nuisance.

Mr. Johnston: Will you explain what you mean by yielding supports?

Mr. Sperr: At great depth it is impossible to support the superincumbent material against its tendency to move downward and fill the excavation; but it is necessary and quite practicable to support the fragments which by becoming detached will fall and do damage. A yielding support is one which yields to the general downward movement without losing its usefulness for the purpose of supporting the detached fragments. For example, a stull or prop set in the ordinary way with a hitch in the footwall and a wedge against the hanging wall, yields but very little to the slow closing-up movement between the foot and hanging walls, before it buckles and becomes useless. But, a support made up with a piece of timber on end like a stull, and with more or less blocking at the top and bottom, will yield until the blocking is crushed to pulp, thus greatly prolonging the life of the stull. Concrete yields even less than timber on end. Steel has more yielding quality, but its replacement or repair is much more difficult.

FOLLOW-UP SYSTEM AND METHOD OF RECORDING INJURIES IN COMPLIANCE WITH THE "WORKMEN'S COMPENSATION LAW."

BY HERBERT J. FISHER, IRON RIVER, MICH.*

In 1912, at an extra session of the Michigan State Legislature, Act No. 10 was passed, providing compensation for accidental injury to, or death of employes, methods for the payment of the same, and creating an Industrial Accident Board. Since that time, many systems for handling compensation have been devised by various mining companies, the complexity of each system depending largely upon conditions in the mine, and the number and class of employes engaged in the work.

Accidents naturally divide themselves into two classes, minor and serious. Government statistics show that eighty per cent of all accidents are minor, while only twenty per cent are either serious or fatal. It has been found that a large number of the minor accidents become serious through infection, if not given prompt attention, and that this inattention is due mainly to the fact that most men believe that slight lacerations do not need to be cared for by a physician or nurse, and that many others, after having had a first dressing, do not believe subsequent dressings or attention necessary.

It is my purpose, in dealing with this subject, to present in detail a system which has thus far proven very efficient in eliminating the carelessness and indifference on the part of the men, in accurately checking every movement of the injured workmen from the time of injury to the time when he is able to resume work, and in handling compensation as required by the law. Although five of the mining companies in the Iron River district are using practically the same system, I wish to refer more especially to the method followed by the Munro Iron Mining Company, Iron River, Michigan.

*Cashier Munro Mining Company.

Form 181.

NAME ....His signature............ Check No......
Munro Iron Mining Co........Mine. Date of employment........19...
Age ....Nationality ....In what country born............
His present place of residence ....
Weight ......Height ....Complexion ....Married or single.....
Color eyes ....Color hair ....Mustache ....
Give distinguishing marks ....
....
....
Describe any deformities or permanent injuries.................
....
....
Father's name ....Mother's name ....
Father's address ....Mother's address ....
Wife's name and address ....
....
No. of children, name and age of each ....
....
Names and address of other relatives ....
....
....

PLATE No. 1 (FRONT OF CARD)

What work is he experienced in?.................................
How long engaged at this work?.................................
Offered employment as ....
Give drink habits in full ....
....
....
Can he speak English?...........Can he read English?..............
Can he write his name?........How long in this country?............
Has he first papers?...........Has he second papers?...............
Where and when has he worked for M. I M. Co. before?.............
Where employed previous to obtaining employment with this Company? ....

	Last Place.	Next to Last.		
Cause of leaving	....	....	......	...
Date of leaving	....	....	......	....
How long did he work there?	....	....	......	....
What work engaged in?.....	....	....	.....	....
Name of Mine	....	....	......	....
Name of Company............	....	....	....	....

Date and reason for leaving M. I. M. Co.............................
....
....
....
....
....

PLATE No. 1 (BACK OF CARD)

Plate No. 1, in two parts, shows an identification card. All but the fourth question, of part two is filled in by the timekeeper as soon as a man is employed. When an employe's drink habits are ascertained, the captain or foreman sends a note direct to the General Office with the desired information, which is entered on the card. This card gives definite information as to all dependents, and refers to the different places where the applicant has worked during the year. This

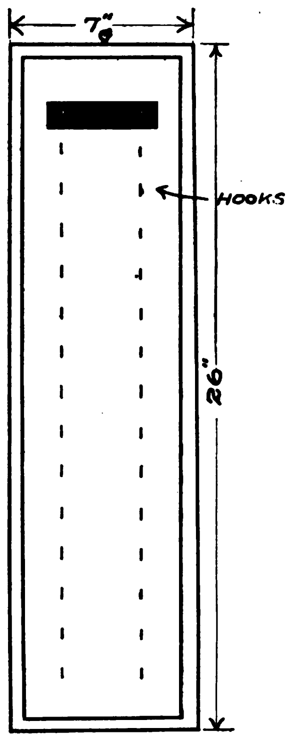


PLATE - 2

PLATE NO. 2 (REGISTRY BOARD AT MINE)

information is used in computing the average weekly wage. The card also gives some idea of the workmen's drink habits, which information is vital in reducing to a minimum the number of accidents, and in raising the average resistance to infections.

All captains, foremen, skip-tenders, drymen, and timekeepers are warned to be on the lookout for all injuries no matter how slight. When an injury is discovered, the man is sent to the doctor for attention, and the timekeeper is reported to, and he in turn reports by telephone to the General Office. The timekeeper then makes out a card showing the date, name, and nature of the injury. This card is then hung on a registry board, as shown in Plate 2, the board being provided with small hooks for holding the cards.

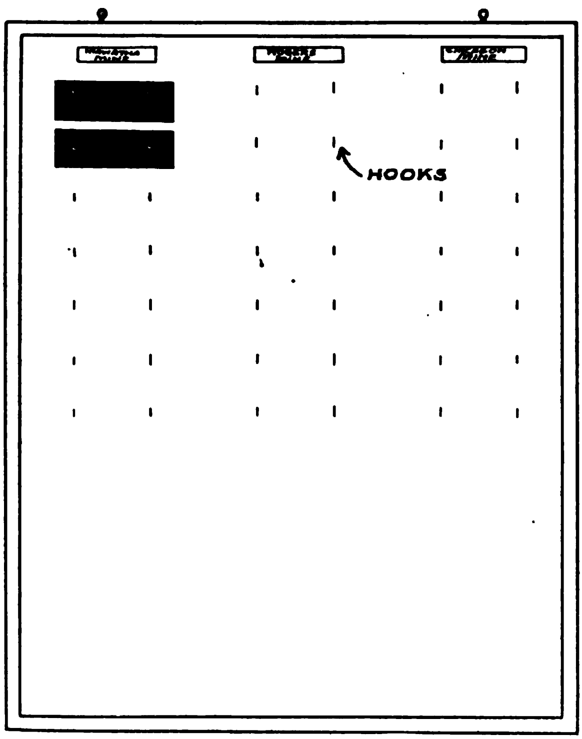


PLATE-.3

Plate No. 3 (General Office Registry Board)

The board is kept where the captain and foremen can easily refer to it before taking their shift, and they are not allowed to let a man go to work whose name appears on the registry board.

The timekeeper also makes an accident report, giving briefly the history of the accident, together with written statements of witnesses, and this is forwarded to the General Office as soon as possible. The General Office, upon receiving the timekeeper's telephone report, telephones to the hospital, and makes out a card similar to the timekeeper's, and posts it on a registry board (Plate 3) hung in the General Office.

As soon as the hospital receives the report from the General Office, a card is filled in (Plate 4) and inserted in a

Name.		
Mine No.	**Hosp. No.**	**Date Injury.**

Plate No. 4 (Hospital Registry Board Card)

registry board, kept in the hospital (Plate 5), in the column under the day of the week in which the man was injured. If he does not appear on that day, the hospital telephones the General Office, and the compensation clerk takes immediate

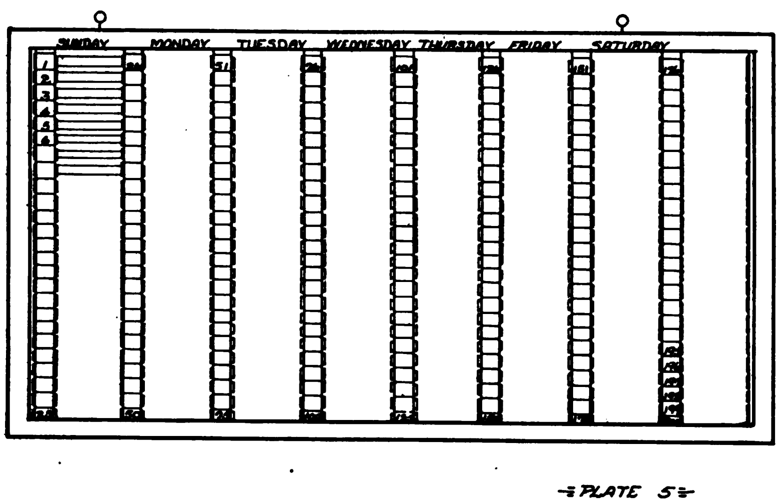


Plate No. 5 (Hospital Registry Board)

steps to locate the injured workman, to see that he reports to the physician or hospital. When he has received his dressing, a hospital card (Plate 6) is filled in, and a physician's report (Plate 7) is made.

SURGEON'S REPORT OF ACCIDENT.

No...........

........................Mine. ....191....

1. Name .... Check No...........
2. Address .... Occupation ....
3. Nationality ..Age ..Married?..Children under 16 years of age...
4. Height ..ft..in. Weight...lbs. Chest...in. Hair...Eyes...Skin...

---

5. Injured ....191 ....M.
   Dr. notified ....191 ....M.
   Received ....191 ....M.
6. First aid by Dr......................at......................
7. Treatment by Dr......................at......................
8. Assistants ....
9. Interpreter?...........Name and address ....

---

10. **Statement of Injured Person as to Manner in Which Injury Was Caused.**

....
....
....
....
....

---

11. Injuries ....

See Diagram } ....
....
....

---

12. Treatment ....
....
....

---

13. Disposition of patient ....
14. Probable result ....
15. Probable period of disability ....
16. Previous condition and evidences of old injury.................
....

---

17. Insurance carried ....

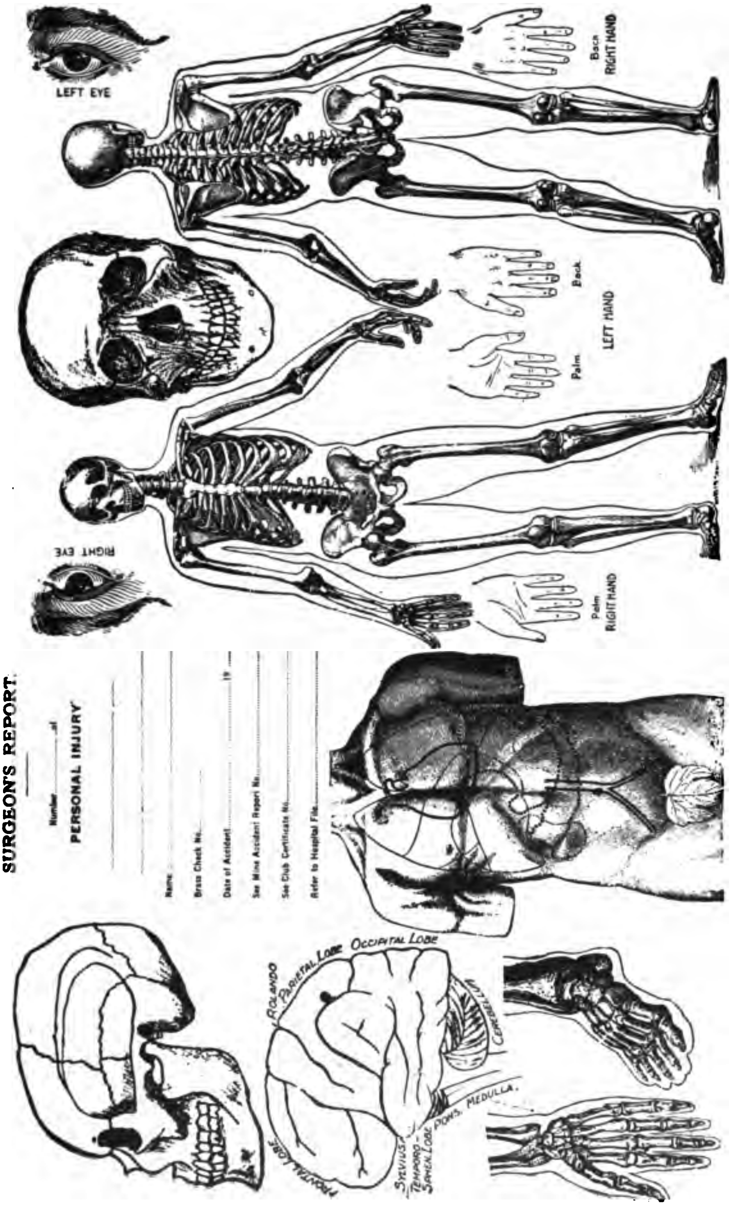
---

18. Witnesses ....
....
....
....

Refer to Hospital File No..............

..............................Surgeon

Plate No. 7 (Surgeon's Report)



BACK OF PLATE NO. 7 (SURGEON'S REPORT)

Form 2

MERCY HOSPITAL
IRON RIVER, MICH.

FILE NO.

Name .... Residence ....
Occupation .... No .... Married? .... Children under 16 years ....
Age .... Nationality .... Ht .... ft .... in. Wt. .... lbs. Chest .... in. Hair ....
Injured .... 19 First Aid by Dr .... at .... Eyes ....
Call In .... 19 Treatment by Dr. .... at .... Comp. ....
Received .... 19 Assistants ....
Interpreter? .... Name and Address ....
Statement ....
Injuries ....
Treatment ....
Disposition of patient .... Probable result ....
Probable period of disability .... Old Injury? ....
Witnesses ....
Club .... 19 .... To .... 19 ....

Dates Seen	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Insurance ....

PLATE NO. 6 (HOSPITAL CARD)

The form Plate 6 is kept on file at the hospital, and the form Plate 7 is forwarded to the General Office of the Mining Company. The injured man is then given a dressing card and envelope (Plate 8 and 9), which he carries with him. He is

O	
R	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
H	

Form No. 151.

..................................Mine. Hosp. File............

SURGEON'S CARD.
Notice to Injured Employe.
READ THIS.

This card is to notify you that, during the continuance of your disability, you are to report to the surgeon for examination as directed by him. If you refuse, your right to compensation will be suspended. Bring this card with you each time you report to the surgeon.

Bearer .... Check No.........Is not/now ready to work
Date ....Surgeon.

(Note): H—Hospital Treatment.
R—Home Treatment.
O—Office Treatment.

PLATE NO. 8 (DRESSING CARD)

.... **Mine**

EMPLOYEE'S DRESSING CARD

Name.. **Check No.**.........

Address ....

KEEP THIS CARD CLEAN

Do Not Fold, Bend or Break It

PLATE NO. 9 (DRESSING CARD ENVELOPE)

then advised when to report for another dressing. The small card (Plate 4), is then inserted on the regsitry board (Plate 5) in the column under the day of the week in which he must appear for his next dressing. The physician's registry board shows at a glance what men are due for dressing or attention. In case the injured man does not appear, as requested by the physician, the General Office is again notified, and immediate steps are taken to locate him and see that he receives the proper attention.

When the injured party is able to resume work, the physician scratches out the word "not," on the dressing card (Plate 8), and signs it. The injured man then presents the dressing card to the foreman at the mine, and if it is satisfactory, he is put to work. Later the foreman checks with the mine registry board so as to be sure there is no error. In the meantime the physician fills in a postal card (Plate 10), and

This is to advise that ....
No...............Our File No..............has received complete Dressing Card and was ready to resume work ....191..
.............................Surgeon.

PLATE NO. 10 (POSTAL CARD)

forwards it to the General Office. The Office in turn reports to the timekeeper, and he takes out the card posted on the mine registry board (Plate 2).

It is the duty of the physician, when an injured man appears for his first dressing or treatment, to report it at once by telephone to the General Office, except in cases where the Office has already reported to him. Therefore, in the case where a man with a slight injury goes unobserved by any one at the mine, but later goes to the hospital for treatment, the General Office will get a telephone report from the hospital, whereupon they will then refer to their registry board (Plate 3). If no card is found for the injury, one is made out, placed on the board, and the injury is reported to the timekeeper at the mine, who duplicates the Office card, and hangs it on the mine registry board (Plate 2). The injured man is then unable to return to work until he has received his completed dressing card (Plate 8) from the physician.

In giving the above detail, I wish to impress the value of the double-check system. At first reading it may seem burdensome, but in actual use, it is simple and logical.

The value of any system depends upon the results obtained, and what is needed most in handling these "injured cases," is a system wherein a man is compelled to report and receive attention. Every skip-tender, foreman, dryman, captain, and timekeeper, knows it is his duty to report an injury, no matter how slight. The compensation clerk and physician know that it is their duty, after being reported to, to see that the injured receives systematic attention, and when anyone fails to perform his special duty, that failure is easily traced. The error of one is reflected by that of another through a central point, in this case, the General Office.

When the Munro Iron Mining Company first installed this system, considerable difficulty was encountered, but after a number of cases had been carefully checked, the whole scheme seemed to implant itself in the minds of all, and at present it is an exception when a complete check has to be made. It has also been found that it is quite unusual for a man with even a slight injury to leave the mine without its being known, whereas under the old system most of the minor injuries were not known until a physician's report was received, and by that time many of these cases had become infected.

Compensation.

In handling the compensation part of this paper, I am not going into the details of the compensation law and its requirements, for these are no doubt familiar to most of the mining men, and are easily obtained by reviewing the law on the subject.

Mine ....

Name .... Mine No. .... Address ....

Date of Injury .... Hour .... Age .... Married or Single ....

Occupation .... Character of Injury ....

Cause of Accident ....

.... Part Disability ....

Fatal .... Permanent Disability .... Disability From .... To ....

In case of DEATH, Length of Disability before Death .... Average Weekly Wage at time of Injury....

RECORD OF EARNINGS FOR PRECEDING YEAR. Acc. Report No. ...... Phy's Report No. ... Hosp't File No. .....

Company.	Occupation.	Length of Service From	Length of Service To	Rate Per Week.	Computed Average Weekly Wage For Preceding Yr.
					Amount to be Paid Per Week
					How to be Paid. Weekly, Monthly or Lump Sum.
					Date of Payments
					Approved By

Amt. Paid For Doctors $ Hospital $ Burial $

RECORD OF DEPENDENTS.

Name in Full.	Address in Full.	Relation	Age	Name of Administrator.	Address.	Proportion of Payment

Date of Reports Sent to State.		Remarks.
Form 5A	6	
7	10	
11	12	
Date of Approval............		

Pmts	Date	$ Amt	Date	$ Amt	Date	$ Amt	Date	$ Amt	Date	$ Amt	Date	$ Amt	Date	$ Amt	Date	$ Amt	Date	$ Amt	Date	$ Amt
1																				
2																				
3																				
4																				
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31																				
32																				
33																				
34																				
35																				
Total																				

INDEX D-55.

PLATE NO. 11 (OFFICE RECORD)

In the General Office of the Munro Mining Company, at Iron River, Michigan, are two separate sets of vertical filing cases. One contains all the reports required by the state, the special folders for each injury being arranged in alphabetical order according to the names of the men injured, together with all correspondence in regard to each particular case. In the other case is filed the history of the case in the form of accident reports, physician's reports, postal card (Plate 10), and dressing card (Plate 8).

The final record (Plate 11), which is a summary of all the records of the case found in both sets of filing cases, is kept in a loose-leaf ledger. This form is made out as soon as compensation begins, and contains a record of a man's earnings, his dependents, and the state requirements, as well as a statement of the compensation he has received and is yet to receive.

When the form (Plate 11) is complete, it is taken out of the loose-leaf ledger and placed in a storage ledger. From the ledger a balance can easily be drawn showing the total amount of compensation for which the company is liable.

NOTE—Where the work of a number of mining companies is handled by the same physician, a color scheme is used, each company having a different color for its set of cards.

THE ELECTRIFICATION OF THE MINES OF THE CLEVELAND-CLIFFS IRON COMPANY.

BY F. C. STANFORD, ISHPEMING MICH.*

The first electrical equipment used by this Company was installed 34 years ago, in the year 1880. It consisted of an arc-lighting outfit for the illumination of open-pit workings.

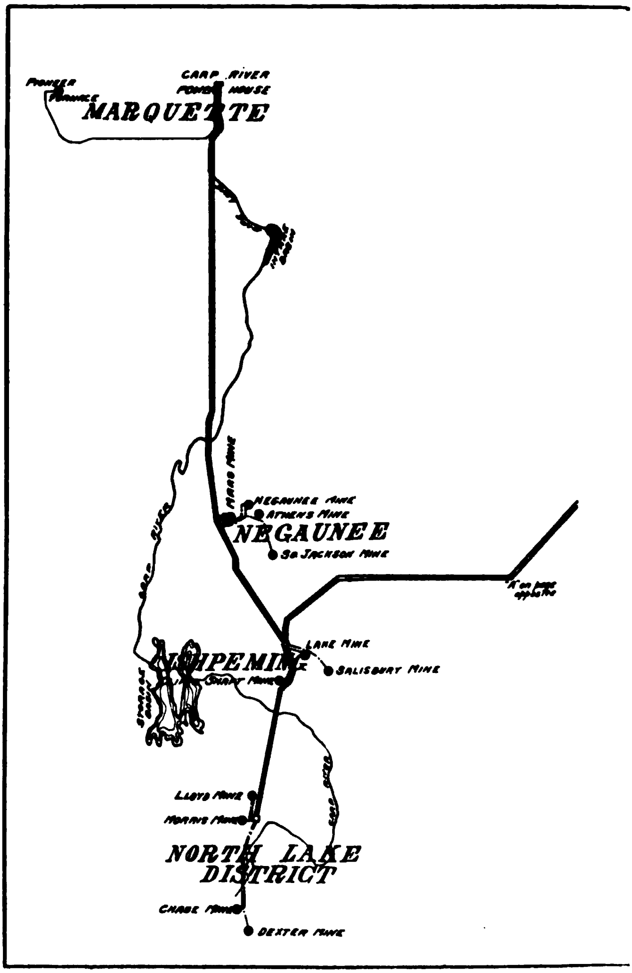
In the year 1894 the Company installed its first electric underground haulage. The original electric locomotives made by the General Electric Company and exhibited at the World's Columbian Exposition are still in regular service. In 1898 two additional locomotives were bought from The Jeffrey Manufacturing Company, and in 1901 one was bought from the Westinghouse Electric & Manufacturing Company. These are all now in use at the Lake mine.

The principal mines of the Cleveland-Cliffs Company are so located that the change from steam to electric power, and the use of electric power for the development of new mines, has been accomplished without difficulty and with very satisfactory results and has proved entirely adequate to meet any conditions that may be expected in iron mining. The map shown on pages 2 and 3 indicates the relative location of mines and the inter-connecting transmission lines. Nineteen mines are now connected by electric lines. Eighteen of these mines are either producing or are under development. In addition to this, the Pioneer Furnace at Marquette is connected to the system.

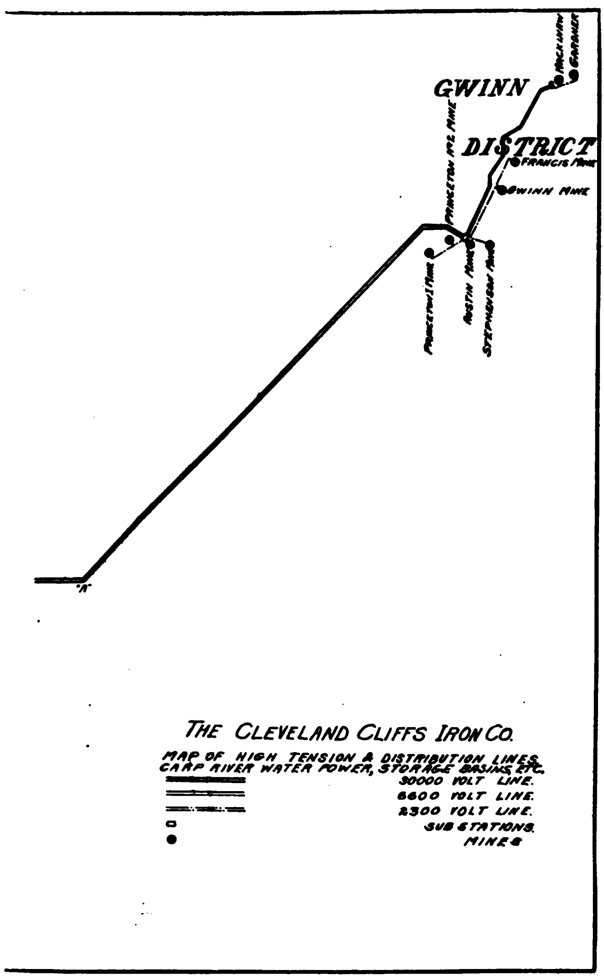
The principal generating station is a hydro-electric plant located near Marquette. This has a normal rated capacity of 5,600 kilowatts. The generating equipment consists of two Allis-Chalmers 2,800-k.w. 2,300-volts 3-phase 60-cycle

*Chief Electrician.

generators direct connected to high-head turbines. The exciters are mounted on shaft extensions outside the main bearings, each exciter being of sufficient capacity to provide excitation for both units if necessary. All circuits are controlled by Gener-



al Electric solenoid-operated oil switches. These are each placed in individual brick-and-concrete compartments, one switch being provided for transformer control, two for generator control and two for local feeders. The 2,300-volt bus bars are carried in brick-and-concrete compartments and have sectionalizing disconnecting switches. The high-tension bus bars are carried open on wall-mounted insulators to the disconnecting switches and high-tension circuit breakers. The high-tension transformers consist of three Allis-Chalmers 1900-k.v.a. trans-



formers, 2300/30,000/60,000 volts, connected delta. The station wiring for the 2300 volts is varnished-cambric double-braid insulation carried in fibre conduit. One of the local feeders supplies the station lights and miscellaneous power for operating the auxiliaries. The other local feeder is carried to

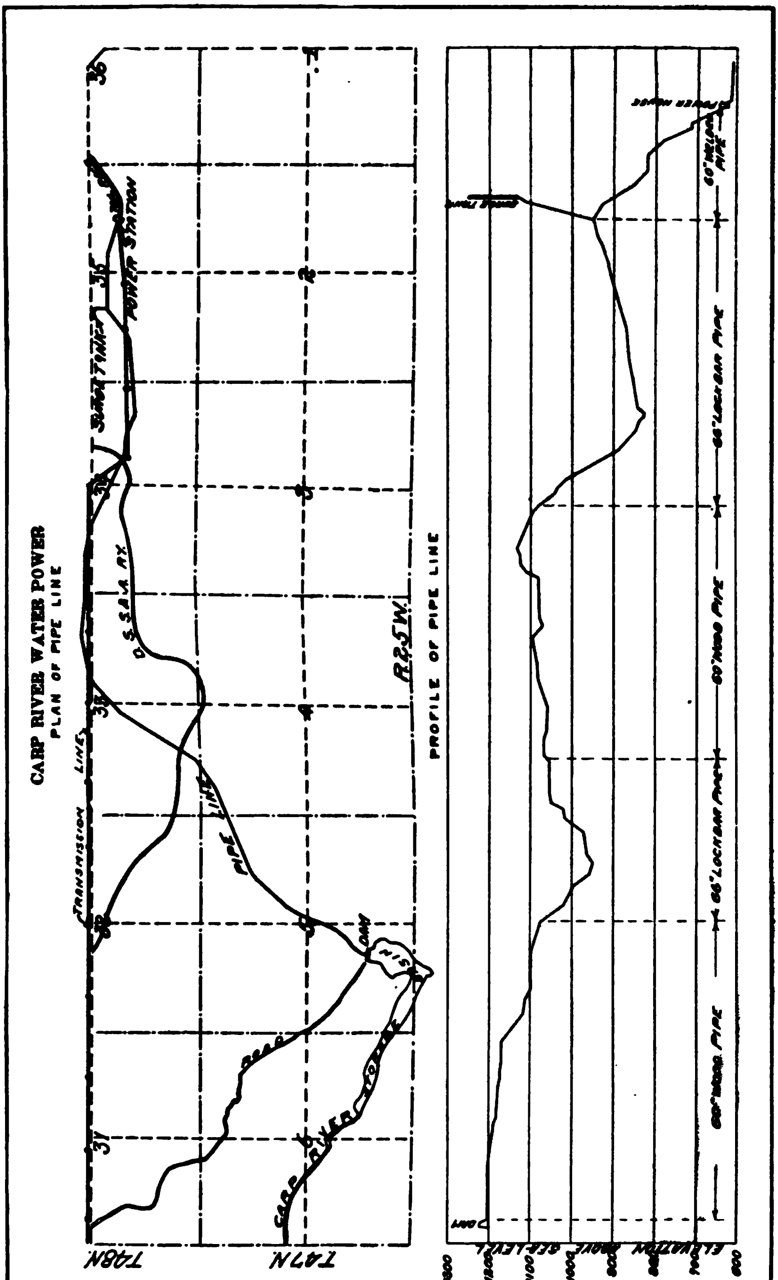
CARP RIVER POWER HOUSE—SHOWING GENERATING EQUIPMENT AND HIGH TENSION TRANSFORMERS.

three 2300/6600-volt General Electric oil-and-air-cooled transformers to supply the 6600 volt power for the Pioneer Furnace line.

The drainage area of the Carp River, from which the power is derived, is about 70 sq. miles, and the average flow in a dry month is .4 cu. ft. per second per sq. mile of drainage area. The stream discharge has been found, however, to be 1.25 sec. ft. per sq. mile during the 7 months of the year when the flow is greatest. The equipment, therefore, was proportioned on the basis of this flow, the expectation being that as the load built up, steam reserve plants would be used during the low-water periods.

The Carp River dam is located about four miles from Lake Superior and the total fall between the dam and the power house is 600 ft., giving an average working head of 580 feet. The dam consists of a monolith concrete structure, cuts of which are shown.

The pipe line connecting the dam with the generating station consists of 10,000 ft. of 60-in. wood-stave pipe supplied by the Pacific Coast Pipe Company; about 9,000 ft. of 66-in. steel-lockbar pipe furnished by The East Jersey Pipe Company; and for the high-pressure section near the power house, about 2,000 ft. of 60-in. seamless welded pipe furnished by Thyssen & Company of Bremen, Germany. The pipe line, as shown by the cuts, passes through a very rough country, and in order to hold the pipe in position concrete anchorages were placed at grade changes where the pipe tends to rise. The delivery of the material used in the construction of the pipe line, which ordinarily is a considerable factor in the expense of construction, was accomplished by a somewhat novel method. The grading for the pipe was completed and upon this a temporary track was laid. At two different points the railway track passed over the pipe line location and at these points switches were provided. The material was transferred here from the railroad cars to trucks and delivered to its final position. At 1400-ft. intervals suitable air valves were placed. To prevent freezing, these were first enclosed in a wooden box and the box packed with manure. This froze solid. The valves were then enclosed within stone walls and covered with plates with the expectation that the dead-air space would prevent freezing. This entire structure was covered with earth and the ventilator packed in mineral wool. This, however, did not prevent freezing. The final method


CARP RIVER WATER POWER
PLAN OF PIPE LINE
TRANSMISSION LINE
PIPE LINE
POWER STATION
D.S.S.&A. RY.
ROAD
CARP RIVER
DAM
T48N.
T47N.
R25W.
PROFILE OF PIPE LINE
ELEVATION ABOVE SEA-LEVEL
66" LOCKBAR PIPE
60" WOOD PIPE
1300
1200
1100
1000
900
800
700
600

adopted consisted of enclosing the valve within the stone structure in a wooden box and packing this portion full of mineral wool, leaving a suitable vent in the top. This has proved entirely satisfactory and valves have not frozen since this method was adopted.

In order to equalize the stream flow and conserve the run-off of the stream during the flood period a storage dam was constructed near Ishpeming. This dam contains about 1800 cu. yds. of masonry, has a spillway 150 ft. long, and a 60-

STEPHENSON MINE. PANELS FOR UNDERGROUND PUMPS

in. butterfly valve to control the flow. The approximate capacity of the storage basin is 435,000,000 cu. ft. of water and its area is approximately 1000 acres.

The water turbines were furnished by the Allis-Chalmers Company. They have cast-iron spiral casings and are designed for 550 ft. effective head, a normal speed of 700 ft. per minute, and a normal capacity of 4000 h.p. each. The runner is of bronze, cast in one piece and keyed to a forged-steel shaft. The casing is made in the form of a true involute spiral, so that the area changes in direct proportion to the amount of water discharged into the guide casing, which gives theoretically a constant velocity of flow with minimum loss. These turbines are balanced hydraulically, the thrust due to the action of the runner being automatically counter-acted by a suitable proportioning of the annular space on either side of the runner. The draft tubes are about 20 ft. long and 40 in. in diameter, and are built of 1¼-in. steel slightly tapered to reduce the velocity. Each unit is controlled by an oil-pressure regulator so designed that the pressure may not increase to exceed 12 per cent under sudden changes of load. The oil-pressure system for the operation of these governors was supplied by the Allis-Chalmers Company and is operated by 15-h.p. 110 volt motors driving rotary pumps. The speed regulation under the governor control is according to the following table:

Load Change, Horsepower.	Speed Variations, Per Cent. Load on.	Load off.
2,000	8.0	5.5
1,500	6.0	4.0
1,000	4.0	2.5
500	2.2	1.5

For equalizing the pressure in the pipe line a surge tank was erected at the beginning of the high-pressure line upon a point called Mt. Mesnard. This surge tank is of steel, 16 ft. in diameter and 124 ft. high. To prevent freezing in the winter the tank is covered with wood lagging.

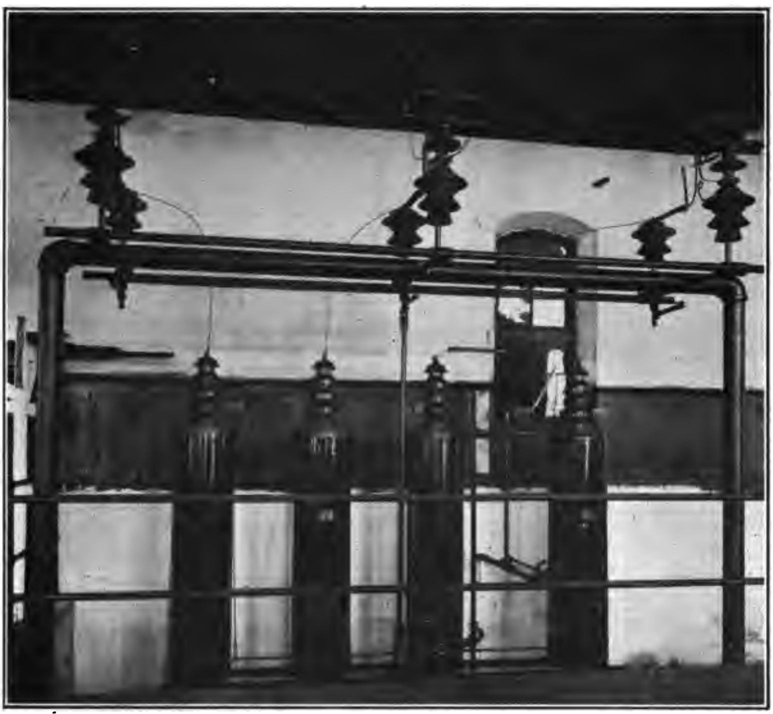
Steam Reserve.

The auxiliary reserve steam plant consists of two steam turbo-generator sets each rated at 1000 k.w., but designed to carry 1500 k.v.a. each for short periods. These stations are duplicates, one being located at the Maas mine, Negaunee, and the other at the Central Power Plant, Princeton. At each station steam is supplied by Stirling boilers with Murphy automatic stokers. The furnaces are built with out-set front, Dutch-oven effect, with coal bins above supplied from overhead cars. The plants are equipped with Sturtevant economizers and operate by induced draft.

The turbo-generator sets and all auxiliary apparatus were supplied by the Allis-Chalmers Company. The turbines operate at 1800 r.p.m., 2300 volts, and have the exciter on a shaft extension. An auxiliary exciter is motor driven. Full switchboard equipment is provided, including voltage regulators and necessary instruments and feeder switches. Tomlinson barometric condensers are used.

Transmission Lines.

The high-tension transmission line is designed for 60,000 volt operation, but at present only 30,000 volts are in use. The total length of the high-tension transmission line is 38 miles. There are four substations. The line consists of two 3-phase circuits of No. 2 solid hard-drawn copper wire



General Electric Lightning Arrester Mounted in Sub-Station at Ishpeming

carried on steel towers. The guard wire is 5/16-in. steel strand. R. Thomas & Sons insulators were used exclusively, and the wires are attached thereto with Clark insulator clamps. The four substations are practically duplicates, each containing three 590-k.v.a. Allis-Chalmers transformers, 30,000/60,-000/2300 volts, connected delta; two high-tension circuit breakers furnished either by the Allis-Chalmers Company or the Westinghouse Electric & Manufacturing Company; and two sets of 60,000-volt, 3-phase, ungrounded neutral electrolytic lightning arresters, part of them furnished by the General Electric Company and the others by the Westing-

STANDARD CONSTRUCTION OF HIGH TENSION TRANSMISSION LINE

house Company. The distribution lines from the substations to the mines for all distances up to two or three miles are standard pole-line construction for 3-phase, 2300-volts. These lines vary in size from No. 2 to 300,000 C. M., depending upon the load to be carried and the distance. For longer distances, up to five or six miles, 6600 volts is used. These are connected through General Electric oil-and-air-cooled 2300/6600-volt transformers.

One motor-generator set located at the Pioneer Furnace is driven by a 600-h.p. 6600-volt 3-phase synchronous motor furnished by the Allis-Chalmers Company. Aside from this the standard practice is to use 2300 volts for all service above 25 h.p. and 220-volt motors for all smaller sizes. Lighting in

STANDARD POLE-LINE CONSTRUCTION

mines and mine buildings is at 220 volts, and for the locations, at 110 volts. All distribution lines are protected by either Westinghouse or General Electric 3-phase electrolytic lightning arresters.

The principal uses for current are as follows: Hoisting, Tramming, Air Compressors, Underground Pumps, Surface Pumps, Underground Haulage, Miscellaneous Power, Lighting, Signal Service, etc.

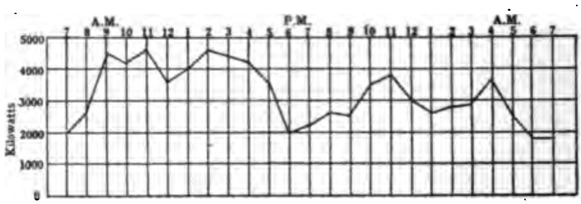
The following table shows the amount of current used in a typical month:

	Kilowatt-Hours.
Hoisting	219,700
Tramming	16,900
Air Compressors	497,800
Pumps	398,600
Underground Haulage	109,600
Miscellaneous Power	131,200
Shops	9,100
Lighting	41,100

The total motor load now connected is approximately 16,000 h.p., comprising 4,500 h.p. in synchronous motors and 11,500 h.p. in induction motors.

As most central station men consider mine service very severe a curve of our daily load is herewith shown.

While this curve shows a fairly wide variation of load, and some high peaks, there are no serious fluctuations in voltage such as will impair lighting service.



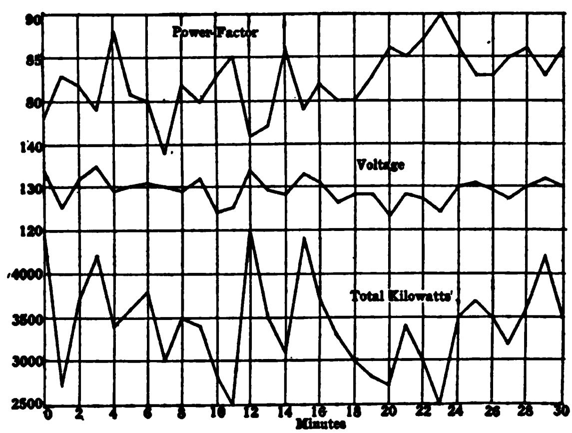
LOAD CURVE AT THE CARP RIVER PLANT FOR ONE DAY, MARCH 27, 1914

All wiring in and about mines must be as nearly perfect as possible, not only that the service shall not be interrupted but also for the protection of employes. Particularly is this true underground, where the wires may not be as closely inspected as in more readily accessible places. Also much of the work of wiring about mines has to be done in unfavorable locations, where there is moisture, etc.

On all installations of primary motors a standard panel is used, equipped with ammeter, volt meter, oil circuit breaker, low-voltage release and watt-hour meter. These panels are usually of slate, but in the future, for underground service all installations will be on pipe-frame mountings only. Marble or slate panels are undesirable because they show a tendency to absorb moisture and dirt, Secondary motors are usually equipped with an oil circuit breaker, low-voltage and overload relays, and watt-hour meter, with wall or pipe-frame mounting.

Fuses are used for the lighting service only.

On wiring for primary motors in power houses and shops varnished-cambric steel-taped cable without lead is used. Secondary motors ordinarily are connected by the usual conduit wiring, R. C. wire being used. For conducting the primary current into the mines three-conductor varnished-cambric insulation rated at 5,000 volts, with lead sheath, jute wrapping and ¼-in. rectangular armor, is used. A special form of hanger has been developed which securely clamps the steel armor without injury, so that when the cable is in the shaft



CURVE SHOWING LOAD CHARACTERISTICS OVER A PERIOD OF 30 MINUTES AT CARP RIVER STATION

the weight is all supported by the armor. Pump house wiring underground is all with lead-copered steel-taped cable. All cables terminate in some approved form of pot head, and the armor and lead sheath are carefully grounded to prevent puncture.

For the direct-current circuits operating the underground locomotives, the feeders' are placed in a 3-in. fibre conduit having a ¾-in. shell. The return wire is bare and is carried outside the conduit. This method is reliable and no trouble has developed.

The placing of the heavy cables in the deep shafts was quite a problem, as space was somewhat restricted and a number of men were needed to guide the cable past obstructions and any failure would have placed them in jeopardy. The best method yet tried for this is to remove the hoist rope from the cage and then clamp the cable and hoist rope together about every 50 ft. and lower the cable into the proper compartment. By doing this work on a holiday, usually no delay is caused in the mine operations. No duplicate cables have been used, as up to the present time there have been no failures in our primary cables.

Cables are usually tested on the reel, and again after in-

INTERIOR VIEW OF NORTH LAKE SUB-STATION SHOWING HIGH TENSION CIRCUIT BREAKERS AND WESTINGHOUSE ELECTROLYTIC LIGHTNING ARRESTERS

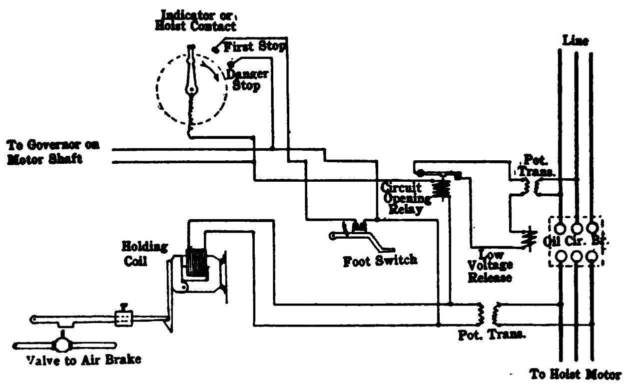
stallation, for insulation resistance, and from time to time re-test is made. We have, with nearly four years service, found no deterioration, but rather an improvement in the insulation resistance. Re-tests are usually made with a 500-volt "Megger," as it is quick and accurate.

Lighting underground in drifts is taken direct from the trolley wire, and at shaft landings and pump houses usually a reserve system of lights from the alternating-current circuit is installed. It is the policy of the Company to use tungsten lamps exclusively, both on surface and underground. For power houses gas-filled lamps are being tried, and if they show reasonable life no doubt they will be used wherever suitable.

On all new installations all wiring will be either in armored cable or metal conduit.

Hoists.

Two types of electric hoists have been developed, each occupying its own field. These are the direct-current hoist, op-



ELECTRIC HOIST SAFETY OVERWIND

erated by the "Ilgner" system, and the induction-motor-driven hoist. Wherever the desired product of a mine can be hoisted in three-ton loads at a speed of 1,000 ft. per minute or less, induction motors directly geared to the hoist are used. Where a greater product is desired the "Ilgner" system is used. The experience which we have had in the past few years in the practical operation of electric-driven hoists indicates that the conclusions arrived at are entirely sound and that the load and speed indicated is the proper division as between the use of the two different types of hoisting apparatus. With a larger generating station, larger induction-hoist motors could be used. In designing hoists for electric drive it is desirable that they shall be made for as low a rope speed as possible, rather increasing the weight of the live load as necessary, than going to high speeds with light loads. The development of each individual hoist, is of course, dependent entirely upon the design and size of the shaft and the amount of ore to be hoisted within a specified time.

At present only one "Ilgner" set is in service. This is a Westinghouse set having a 350-h.p. induction motor, a 400-k.w. 600-volt direct-current generator, a 150-k.w. 200-volt direct-current generator, a 25-k.w. 200-volt exciter and a 25,-000-lb. flywheel mounted on one shaft. The direct-current generators are connected directly to a 500-h.p. 600-r.p.m. first-motion hoist motor for ore skips, and to a 200-h.p. 250-r.p.m. motor with helical gears for the cage or man hoist. The flywheel set has an automatic slip regulator, which by an automatic changing of the resistance in the rotor of the in-

ONE OF THE SUB-STATIONS, NORTH LAKE. OUTSIDE MOUNTING. LIGHTNING ARRESTERS

duction motor, gives a variation of speed from 550 to 720 r.p.m. depending upon the load. The armatures of the generators and hoist motors are connected directly by 1,000.000-c.m. cables without intermediate circuit breakers, the motors having constant excitation in the fields and the control is by varying the field of the generators. This gives a very reliable service, as the flywheel will usually have sufficient stored energy to complete any trip, even if there is an interruption in the current supply. The ore hoist is designed for a 90-second cycle under a 1000-ft. hoist and gives a maximum hoisting speed at full load of 1500 ft. per minute. Curves with tables accompanying indicate the conditions of operation.

TEST OF FLYWHEEL SET.

Depth of Shaft (Sump to Dump) .... 900 ft. vertical
Net Weight of Load per Trip .... 9,290 lbs.

400 H. P. INDUCTION MOTOR DRIVING HOIST AT ATHENS MINE. MOTOR PANEL AND AUXILIARY AIR COMPRESSOR AT THE LEFT AND CONTRACTOR PANELS MOUNTED ABOVE THE HOIST MOTOR.

Weight of Skip (Self-Dumping) .... 5,330 lbs.
Size of Rope, 1¼-in Diam .... 2.2 lbs. per ft.
Hoisting .... Balanced
Size and Shape of Drum ...... Cylindrical, 8 ft. x 66 in. wide
Weight of Drum and Shaft (From Dwg.) .... 31,650 lbs.
Radius of Gyration of Drum .... 3.86 ft.
Total Revolutions of Drum 35.8

Direct-Current Hoist Motor, 500 h.p., 525 Volts, Shunt Wound, 60 r.p.m.

	First Cycle		Second Cycle	
	No. 1 Skip	No. 2 Skip	No. 1 Skip	No. 2 Skip
Time for Hoisting, Sec.........	66.4	86.85	82.9	78.3
Time of Caging, Sec..........	17.9	20.15	16.9	20.2
Maximum R.p.m..	74	71	70.5	75
Maximum Rope Speed, Ft. per Minute	1858	1782	1770	1882
Time of Accelerating	10.5	15.5	20	16
Time of Retarding	36	32	38	47
Average R.p.m...	38.4	29.5	27.7	30.7
Average Rope Speed, Ft.p.m....	965	792	696	772
Maximum Motor Current	1160	2230	1410	1680
Maximum Motor Voltage.......	550	520	520	552
Average Motor Current	495	710	520	683
Average Motor Voltage	276	212	200	222
Average Motor Input, H.p.........	183.2	201.8	139.5	194.2
Average Motor Input, H.p.-Sec..	12150	17500	11560	15190
Motor Copper Losses, H.p......	10.5	21.6	10.8	20.1
Motor Copper Losses, H p.-Sec..	699	1875	895	1573
Average Brake Current	450	235	210	180
Average Brake Voltage	47	62	90	115
Duration of Brake	13	7.75	5.5	5.25
Brake, H.p.-Sec. Generated	368.5	151.2	139.2	145.7
Brake, H.p.- Copper Losses	23.25	16.7	16.55	16.25
Brake H.p.-Sec. Copper Losses.	302 5	129.5	91	85.3
Net Hoisting Work	10780.	15344.3	10434.8	13386.
Average Generator Current	495	710	520	683
Average Generator Voltage	276	212	200	222
Output of Generator, H p.-Sec..	12150	17500	11560	15190
Average Generator Copper Loss. H.p..	12.4	16.15	12.79	15.62
Average Generator Copper Loss, H.p.-Sec..	825.5	1402	1060	1223
Average Wdg. Fr., and Fe Loss H.p.-Sec..	628	674	634	647
Total Generator Losses, H. p.-Sec..	1453.5	2076	1694	1870
Speed of Set at Start of Hoisting	690	680	664	685
Speed of Set at End of Hoisting	655	600	647	662
Speed of Set at End of Cycle...	680	664	685	690
Output of Flywheel, H.p.-Sec...	4200	9000	2000	3000
Input to Flywheel, H.p.-Sec.....	3000	7000	4500	3400
Input to Generator, H.p.-Sec....	13603.5	19576	13254	17060
Input to Alt.-Cur. Motor, H.p.-Sec..	26800	36300	32500	30000
Input to Alt.-Cur. Motor Not Absorbed by Flywheel	23800	29300	28000	26600
Alt.-Cur. Motor Losses in H.p.-Sec..	2145	2575	1928	2045
Slip Regulator Losses, H.p.-Sec.	652	2140	405	504
Shaft, H p.-Sec..	15200	15200	15200	15200
Overall Efficiency	62	44.7	50.2	52
K.w.-Hours per ton	1.1	1.5	1.35	1.3

There are connected the following induction-hoist motors:

Chase Mine, 1 200-h.p. double-reduction geared hoist with direct control—Allis-Chalmers.

Morris Mine, 2 400-h.p. double-reduction geared hoist with remote control—1 General Electric and 1 Westinghouse.

Lloyd Mine, 2 400-h.p. double-reduction geared hoist with remote control—General Electric.

Cliffs Shaft Mine, 1 500-h.p. double-reduction geared double-drum hoist with friction, remote control—General Electric.

Salisbury Mine, 1 400-h.p. single-helical geared double-drum hoist, with friction, remote control—General Electric.

Princeton Mine, 1 200-h.p. double-reduction geared hoist with direct control—General Electric.

Princeton Mine, 1 75-h.p. double-reduction geared hoist with direct control—Westinghouse.

Austin Mine, 1 150-h.p. double-reduction geared hoist with direct control—Westinghouse.

Gwinn Mine, 2 400-h.p. double-reduction geared hoist with remote control—1 General Electric and 1 Westinghouse.

Gardner Mine, 1 400-h.p. single-helical geared hoist with remote control—General Electric.

Mackinaw Mine, 1 400-h.p. single-helical geared hoist with remote control—General Electric.

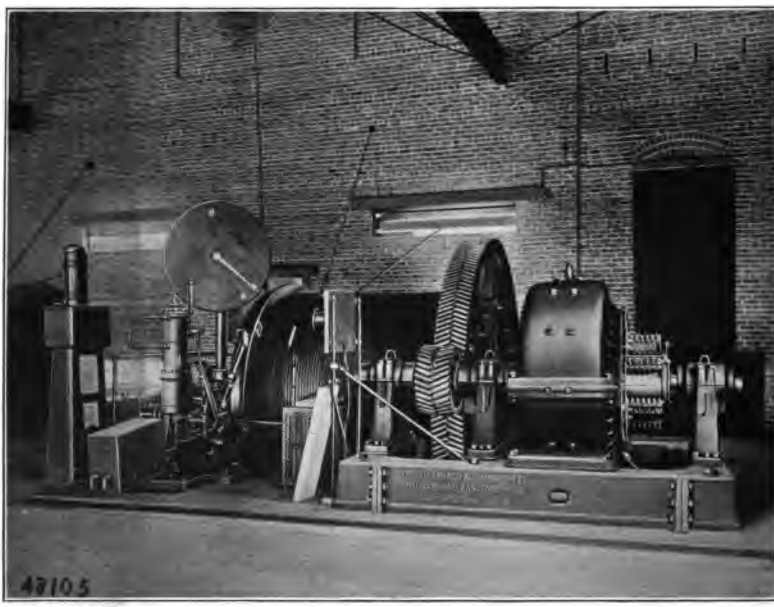
Athens Mine, 1 400-h.p. single-helical geared hoist with remote control—General Electric.

South Jackson Mine, 1 75-h.p. double-helical geared hoist with remote control—Westinghouse.

With the smaller motors we find the direct control, with an oil-immersed primary reversing drum, to be fairly satisfactory when the control is properly designed. The secondary contacts must be of ample capacity and with positive "snap" into position. The primary reversing contacts should have a quick and positive make-and-break before the secondaries come in. The oil tanks should be so designed that oil will not be thrown out, and the leads must be brought out where they may be readily inspected. Ample barriers should be placed between phase leads because with the accurate spotting sometimes necessary with a hoist a quick make-and-break will likely cause surges which may cause a flash-over.

For the control of large hoist motors, solenoid-operated contactors are used exclusively. The only primary switches we have found that are entirely reliable have an air break. While this causes an annoying flash and noise, it is good evidence to the operator that the switch is working properly.

The line-contact points must not make a "butt" contact, but should have wiping contact. This is because the contacts may possibly burn together and fail to open when the controller is thrown off. This form of contact is also best for secondaries for the same reason. Just such a burning together of contacts nearly caused a serious and fatal accident with an old form of contactor which we had in service; the motor failed to stop at surface when the control was off. The single-phase



200 H. P. DIRECT CURRENT MOTOR, DRIVING CAGE HOIST AT NEGAUNEE MINE. ON THE LEFT MAY BE SEEN SIEMENS-HALSKE SIGNAL PEDESTAL

type of control operation seems to be simpler than dividing the contactor closing coils into three phase.

Hoist motors must have very rugged and substantial frames, as the pounding of gears and frequent starts and stops is very severe. Phase leads and coils should be rigidly supported to prevent vibration or distortion under excess current. Adjustable bearing brackets are desirable. The usual excuse that these things are non-essential should not be passed, because when a hoist is once in service it must be ready at all times for service and frequently the lives of men are dependent upon its reliability. The banding of the rotor should be extra strong because of the possibility of overspeed. We require that lowering shall be with the current on to prevent overspeed.

An electric safety overwind has been developed which has been found very reliable. It is similar to most others which have been brought out, but has been somewhat simplified. The operation is as follows:

A contact-making device is attached to the indicator on the hoist with one contact made about 100 ft. below the collar of the shaft. This is controlled by a foot switch operated by the brakeman; if the hoist is under control and the switch is opened it does not operate. The final contact closing is positive and is at danger point. As soon as closed it actuates the circuit-opening relay which trips the low-voltage release, and opens the motor lines. This permits the holding coil to open and operates the air brake. The trip may also be operated by an overspeed governor placed on the end of the motor shaft. If the current supply fails for any reason, the brake immediately sets. It will be observed that this device does not in any sense relieve the brakeman of his responsibility, and while it is in a certain sense automatic in its operation, the intermediate stop, which is under the control of the brakeman, necessitates that he shall have his mind centered upon the work in hand at all times. This practice seems to be more desirable than to introduce a device which would entirely remove "the personal element."

TRAMMING.

The word "tramming" as here used refers to the moving of ore on surface for storage in stockpiles. Two methods are in use, but principally the "endless-rope system" with five-ton cars. This requires from 25- to 50-h.p. motors and is very severe service, particularly in winter when most stocking is done. On account of the location of loading tracks, and other conditions not readily changed, the stocking tracks are usually rather crooked, and because of the many sheaves and rollers the friction load is frequently as high as 75 or 80 per cent. When induction motors are used, they should have exceptionally high torque and a very liberal allowance of grid resistance. The service likely will be at about the rate of one minute on, with possibly 100 per cent. overload at the start, and then one minute off while the car is being loaded. Tramming speed may be as high as 1500 ft. per minute, depending upon the length of tram. Motors for this service must have very heavy and rigid frames, especially so if they are to be equipped with solenoid brakes. In one instance the frame of the motor was broken squarely in two by a sudden stopping with the solenoid brake setting hard.

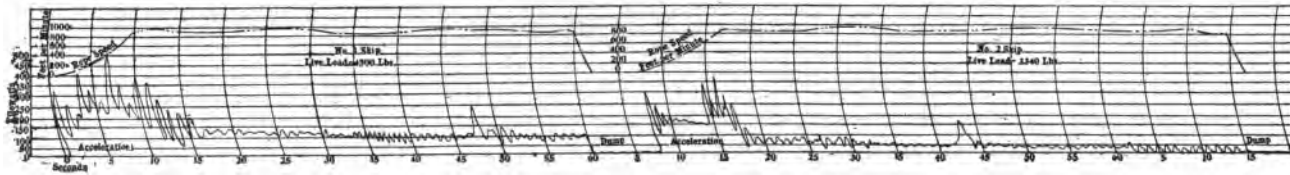
For short trams under suitable conditions gravity tramming is in use and the motor is used only to return the car. Almost any kind of motor answers for this service. (The curve shown indicates the load on one tram which is handled by a 50-h.p. motor.)

AIR COMPRESSORS.

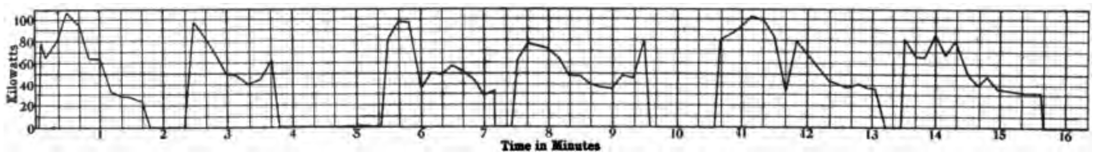
The Cleveland-Cliffs Iron Company has in operation or under erection nine motor-driven air compressors.

UNDERGROUND PUMP AT THE GWINN MINE

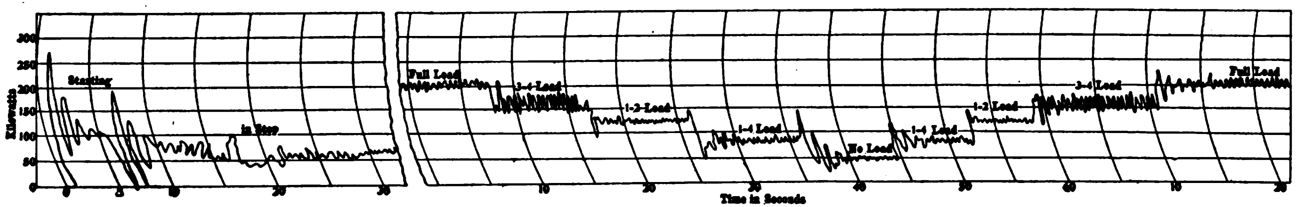
One 4000-cu. ft. rope-driven compressor equipped with a General Electric 625-h. p. synchonous motor with belted exciter. This compressor is not equipped with a variable load device, being an adaptation of a steam-driven machine. An "Erie" valve was placed in the suction and as the pressure drops, this opens the intake and the compressor takes the load. This is rather severe service for a synchronous motor, ranging from friction load to 650-h.p. within a period of two seconds. This installation, however, has given us very satisfactory service and we have experienced no difficulty with this application. The synchronous motor is designed to carry



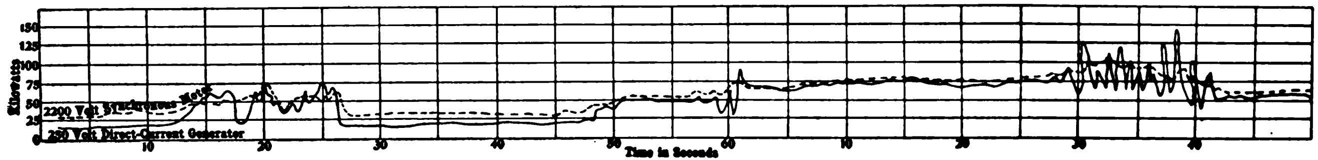
COMPLETE HOIST CYCLE FOR MORRIS MINE ORE HOIST. TWO SKIPS IN BALANCE



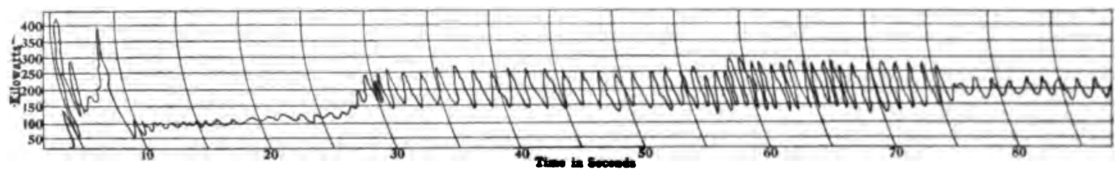
LOAD CURVE FOR STOCKING TRAM, NEGAUNEE MINE. THREE TRIPS OUT WITH LOAD AND BACK EMPTY. HEAVY REVERSE CURVES, 2,400 FOOT TRESTLE, 2,400 FOOT PULLING AND TRAIL-ROPES, CAR WEIGHT, 9,000 LBS., WEIGHT OF ORE, 8,000 LBS. OPERATED BY A 50 H. P. MOTOR.



LOAD CHARACTERISTIC OF A 250 HP SYNCHRONOUS MOTOR. DIRECT-CONNECTED TO A TWO STAGE DUPLEX 1,700 CU. FT. AIR COMPRESSOR. THE FIRST PORTION OF THE CURVE INDICATES THE POWER TAKEN FROM THE LINE TO START AND SYNCHRONIZE THE MOTOR AT NO LOAD. THE SECOND PART SHOWS THE OPERATION OF THE "CLEARANCE CONTROL" DEVICE IN ITS AUTOMATIC REGULATION OF THE COMPRESSING LOAD OF THE MOTOR.



TYPICAL LOAD CURVES FOR MOTOR-GENERATOR SET. THE LOAD CONSISTS OF THE UNDERGROUND HAULAGE OF THREE 6.5 TON LOCOMOTIVES AND 400 16 C-P LIGHTS WITH AN OUTPUT OF 1,000 TONS PER DAY AND AN AVERAGE HAUL OF 5,700 FEET. THE GRADE IS TWO PERCENT IN FAVOR OF THE LOAD.



POWER CURVE FOR A DUPLEX, DOUBLE-ACTING MORRIS MINE PUMP. THE PUMP HAS FOUR PLUNGERS WITH A 6.5 BY 36 INCH STROKE AND IS OPERATED AY A 350 H. P. WOUND ROTOR, INDUCTION MOTOR AT 970 R. P. M. WITH A GEAR RATIO OF 124 TO 14 AGAINST A HEAD, INCLUDING FRICTION, OF 850 FEET. THE OVERALL EFFICIENCY IS 81.6 PERCENT.

over-excitation to correct the low power factor. This compressor is located at the Central Power Plant, Princeton.

One Laidlaw-Dunn-Gordon duplex compressor driven by a 150-h. p. belted Westinghouse induction motor. Located at the Salisbury mine.

One 500-cu. ft. Ingersoll-Rand compressor belt-driven by a 50-h.p. General Electric motor. Located at the South Jackson mine.

One 1100-cu. ft. tandem Allis-Chalmers compressor at the Chase mine, operated by an Allis-Chalmers 175-h. p. induction motor.

One Ingersoll-Rand 1700-cu. ft. duplex compressor with piston inlet valves and clearance control devise, direct connected to a 250-h.p. Allis-Chalmers synchronous motor. Located at the Morris mine.

Tests to indicate efficiences of compressors have been made with orifices and the output computed by Fliegner's formula. These tests are not sufficiently complete at the present time to give duties, but developments are under way and ultimately we will be able to obtain full and accurate information as to the operation of our air compressors.

Several small automatic electric air compressors, driven by 3-h. p. induction motors, have been installed at the various mines as a reserve to operate the air brakes on the hoists. These have proved to be very reliable and satisfactory.

Underground Haulage.

Underground haulage at all the principal mines is with 250-volt direct-current electric locomotives. These are of various manufacture, usually about 6½ tons, and 30-in. gauge. The largest in service is a 10-ton locomotive, but this seems to be somewhat larger than is necessary, as the 6½-ton size will handle all the ore that can be mined. This becomes quite clear when it is understood that a large part of the time in haulage is employed in spotting cars and picking up loads, the actual run to the shaft using but a small portion of the time. Standard construction is with 40-lb. rails, with No. 00 copper bonds at each joint and past switches, No. 00 grooved trolley is used. In a part of the mine this is placed in an inverted trough, in others is entirely open. Very few accidents occur. The Company has 28 electric locomotives in service and one armature winder makes all the rewinds of the 56 motors without trouble and has abundant time for other work. This will indicate the reliability of the modern mine locomotives.

These underground haulage locomotives are driven by motor-generator sets. Five of these sets are driven by 215-h. p. 2200-volt, Westinghouse synchronous motors at 600 rev. per minute. Two sets are driven by induction motors furnished by the General Electric Company. Very little trouble develops in these and they run continuously. About once in two or three years we find it necessary to true the commutators. This is done while they are in service, with a motor-driven grinding machine.

PUMPING.

The drainage of mines being a matter of great importtance the necessity for reliable service in mine pumps is obvious.

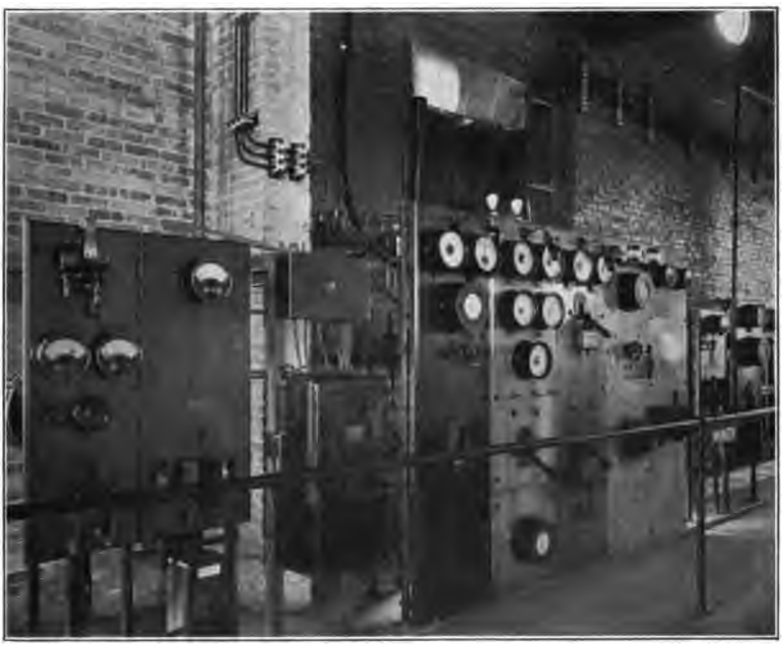
The centrifugal pump on account of its naturally high speed and rotary form lends itself very readily to motor drive. Unfortunately, however, from a mechanical viewpoint it is very much lacking in efficiency. About the best that can be expected from a 1000-gallon-per-minute pump designed for 1000-ft. head is 60 to 95 per cent. efficiency, depending upon the condition of the impellers, packing, clearance, etc. Having the advantage of low first cost these make a very satisfactory reserve or temporary pumping outfit. This is the use given them by The Cleveland-Cliffs Iron Company. Each mine has a centrifugal pump installation equivalent in size to one of the regular units and these are used only for temporary service or in case of emergency. Tests made with a V-notch weir gave the following efficiencies:

OVER-ALL EFFICIENCIES OF MOTOR-DRIVEN MINE PUMPS.

	Total. Head Ft.	Gallons Per Min.	Over-all Efficiency.
Six-stage Centrifugal Pump	933	987.8	54.1
Duplex Double-acting Geared Plunger Pump	833	991.8	84.9
Triplex Single-acting Geared Plunger Pump	409	303.8	81.7
Four-stage Centrifugal Pump	409	288	51.3
Duplex Double-acting Geared Plunger Pump	509	1406	81.8
Five-stage Centrifugal Pump	498	1153	56.9

The mine drainage is principally by means of duplex, double-acting, plunger pumps, although a few small triplex pumps are in use. These are driven mostly by induction motors with single-reduction gears. These gears gave considerable trouble, but of late all pumps have been equipped with helical-cut gears and very little trouble occurs.

It is important that all motors for this service shall have as nearly waterproof insulation as can be applied, as it is usually more or less damp underground and occasionally water will break through and cover a motor. We have never had a burn-out in this class of service and all mines are elec-

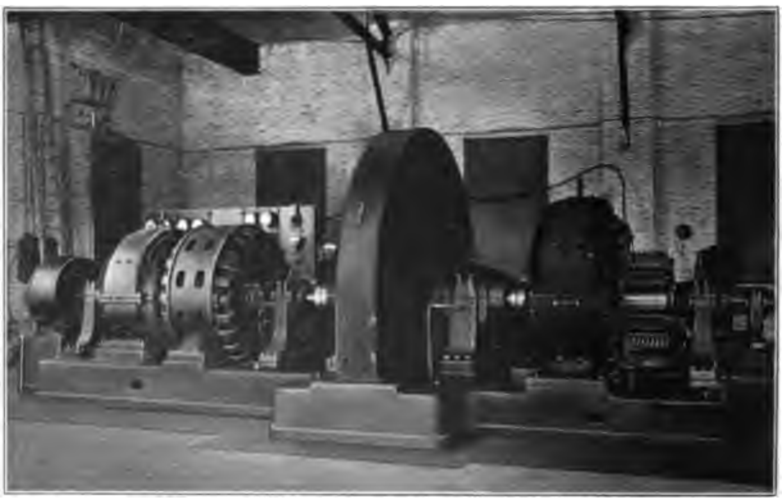


SWITCHBOARD AND MOTOR PANELS AT MORRIS-LLOYD MINE

trically equipped. Primary motors exclusively are used for this service.

The most interesting underground pump installation which we have is the equipment at the Negaunee mine. This consists of two Prescott duplex, double-acting, power-driven mine pumps directly connected to 300-h.p. General Electric synchronous motors. These pumps are rated at 1000 gallons per minute, 1000 ft. head, and operate at 120 rev. per minute. This gives a piston speed of 480 ft. per minute.

These pumps at first were equipped with metal valves and seats. On account of wire drawing and excessive wear due to the mine water these were found unsatisfactory. New valves have been designed, with "Balata" and fibre seats, and the difficulty is corrected. The slippage in these pumps up to the present time has been somewhat excessive, being about 5 per cent. more than the estimate, but with the introduction of the new form of valves and springs of suitable design we believe that this will very soon be corrected. In order that these pumps may at all times have a full supply of water in the suction, small volute pumps, driven by 15-h.p. General Electric induction motors, were placed in the suction. These



WESTINGHOUSE FLY WHEEL SET AT NEGAUNEE MINE

were designed to deliver to each pump approximately 1200 gallons per minute at a 30-ft. head. This should assure a full water supply at all times. The synchronous motors are provided with motor-driven exciters and complete switchboard equipment in each pump station. In addition to the two direct-connected pumping units, a centrifugal pump, manufactured by the Alberger Pump and Condenser Company and rated at 1000 gallons per minute against 1000 ft. head, was installed at this mine. This is driven by a General Electric 350-h.p. Form P., induction motor having a synchronous speed of 1800 rev. per minute.

We have found that underground pumping by electric drive is thoroughly reliable, efficient and satisfactory in every respect. It is advisable that every pump motor should be in operation at least one or two hours every day, the object being, of course, that the heat developed in the motor under run may drive out the moisture which may be expected in the dampness of underground pump stations. We have not up to the present time considered it necessary to provide transformers for the purpose of delivering low-voltage current into the motors while at rest, and the rule requiring daily operation of every pump motor seems to be sufficient to keep them in good condition.

Other underground pumping applications are small automatic sump pumps operating with the ordinary tank-float arrangement. Another use of pumps is in sinking. We have three electric-driven sinking pumps, one operating at 2,200 volts and the others at 220. These are about 50-h.p. each and are very easy to install and reliable in operation.

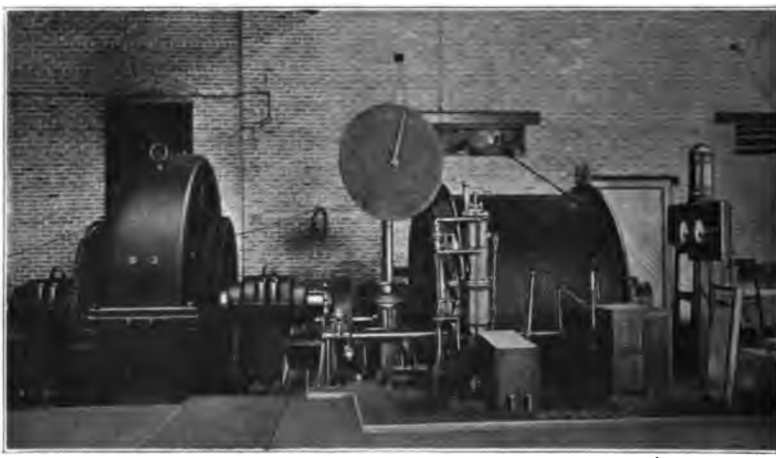
Surface pumping is mostly with small centrifugal pumps, which have a miscellaneous application, for circulating and cooling water, for surface drainage, water supply, etc. These motors range in size from 5 to 40-h.p. and are all of squirrel-cage type.

Following is a list of the underground pumps and motors in service:

No.	Make of Motor	Horsepower	Speed	Geared or Direct Connected	Kind of Pump	Gallons per Minute
3	General Electric	50	1800	Direct	Centrifugal	400
1	Westinghouse	50	1800	Direct	Centrifugal	400
2	Allis-Chalmers	350	430	Geared	Duplex	1000
2	General Electric	400	1200	Direct	Centrifugal	1000
4	General Electric	50	514	Geared	Triplex	400
2	General Electric	300	120	Direct	Duplex	1000
2	General Electric	350	1800	Direct	Centrifugal	1000
1	General Electric	180	600	Geared	Duplex	600
1	General Electric	250	1800	Direct	Centrifugal	600
1	General Electric	75	600	Geared	Duplex	400
1	General Electric	125	1800	Direct	Centrifugal	400
1	General Electric	275	1200	Direct	Centrifugal	1500
1	General Electric	250	600	Geared	Duplex	1500
1	General Electric	320	720	Geared	Duplex	1000

CRUSHING.

Part of the ore mined is hard and requires crushing before shipment. Crusher house service is very severe for motors on account of a varying load and the large amount of ore dust which gets into the windings. Two 125-h.p. squirrel-cage motors are used, each driving a No. 8 McCully gyratory crusher, and two 25-h.p. motors, each driving a No. 5 McCully crusher. Smaller motors are in service for driving screens, etc. The principal trouble that has occurred has been due to cold weather. With no heat in the buildings and temperatures ranging down to 30 degrees below zero, the oil congealed in the circuit breakers and starting compensators. This was relieved by boxing in the apparatus and placing one or two incandescent lamps within. An occasional burn-out occurs in this service, but as it seems to be with all makes of motors, and as the windings are always full of iron ore, that is presumed to be the trouble. The enclosing of the motors



500 H.P. 70 R.P.M. WESTINGHOUSE DIRECT CURRENT MOTOR, CONNECTED DIRECT TO SKIP HOIST AT NEGAUNEE MINE

has been considered, but trouble has been so infrequent that it has not been done.

Small crushers are placed in the laboratories. Usually a 2- or 3-h.p. squirrel-cage motor drives the entire plant. For evaporating, electric hot plates are used. These are very satisfactory and all laboratories are now equipped with them in preference to gas.

MISCELLANEOUS MOTORS.

The usual miscellaneous applications of power motors are made for machine-shop service and to operate sundry auxiliaries. As these are small and perform very ordinary service they are not of especial interest.

SIGNAL SYSTEMS.

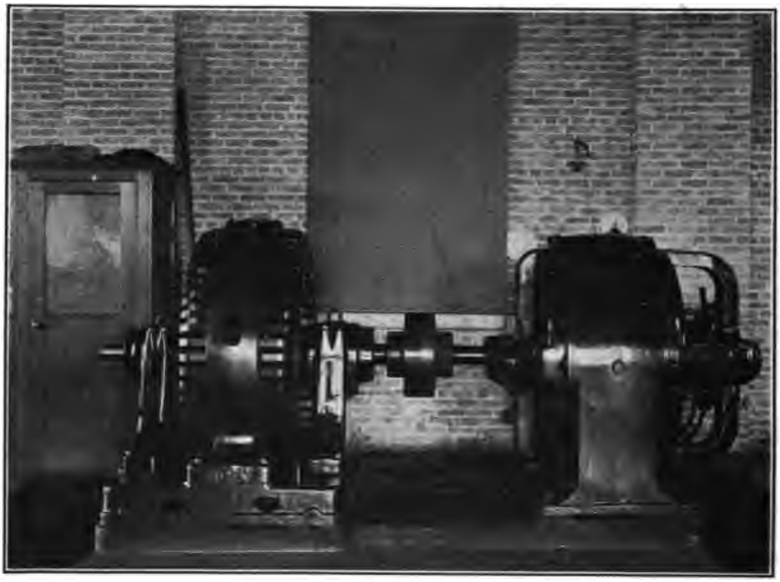
Several different forms of electric mine signals are in use. The most complete is an imported outfit with both visible and audible signals, manufactured by the Siemens & Halske Co., Berlin. Heavy waterproof bells are installed at each level and at landings, these being connected in series and repeating at every point. In the engine room for each hoist is a pedestal outfit having a paper roll which travels about two inches for each signal. Each time the bell rings a hole is punched in the paper ribbon. By a system of lenses, lamps and mirrors a strong beam of light is projected through these holes and

MORRIS MINE POWER HOUSE. 400 H. P. WESTINGHOUSE INDUCTION MOTOR DRIVING CAGE HOIST. 400 H. P. GENERAL ELECTRIC MOTOR ON SKIP HOIST. ALLIS CHALMERS SYNCHRONOUS MOTOR DRIVING AIR COMPRESSOR.

reflected on a ground glass screen. By this method a clear and accurate record of each signal is shown and also a permanent record made on the paper ribbon. The wires for this are rubber covered and in a lead-sheath armored cable. At other mines 110-volt vibrating bells, connected in multiple and repeating at each level, are used. For the pushes, waterproof iron boxes have been developed. Some mines are supplied with single-stroke bells, current being supplied from small motor-generator sets. All of these methods are quite satisfactory. In addition to the signal equipment, regular mine telephones are installed in all mines. The wiring for signals and bells is the same as for National Electric Code 600-volt service. There is a demand for reliable waterproof signal switches and junction boxes.

Testing Instruments.

A fairly complete set of testing instruments has been provided. This consists of galvanometers, a Wheatstone bridge, single-phase and polyphase watt meters, alternating- and di-



UNDERGROUND HAULAGE SET AT NEGAUNEE MINE. FORMERLY THE GENERAL ELECTRIC GENERATOR WAS BELT-DRIVEN. NOW DIRECT CONNECTED TO WESTINGHOUSE SYNCHRONOUS MOTOR.

rect-current volt meters and ammeters, shunts, portable potential and current transformers, a megger, etc.

For locating faults in transmission and distributing lines a slide-wire bridge has been developed. This has proved quite accurate and a ground or cross in the transmission line can usually be located within one or two towers, considerable time and expense thus being saved.

General.

As mine service in general is rather severe and inasmuch as the safety of employes may at any time be dependent upon the reliable operation of apparatus, manufacturers should recognize the demand for rugged and lasting apparatus. When this requirement is fulfilled, the application of electric drive to mining machinery shows a very marked saving in cost of power and a decided gain in reliability of service.

On the part of operators, constant and thorough inspection is essential. Motor clearance must be tested frequently. Oil switches must be carefully cared for and kept in perfect condition. The oil must be frequently changed and tested for moisture. Control apparatus should be gone over daily and contacts kept clean and properly adjusted. Meters should be frequently tested and readings checked to locate quickly any loss in efficiency or defect in the operation of apparatus. Mine electricians should be trained to observe all mechanical equipment used in connection with motor drive and to know when it is in proper condition, because of the usual habit of mine employes to blame any trouble on the electrical part of the equipment.

If these simple rules are observed electrical drive in mines will be found to be an ideal application.

Discussion.

(Note: Discussion by Mr. Kelly is printed on page 68 and applies also to the paper on the "Use of Electricity at the Penn and Republic Mines.")

Question: How much does electrical storms affect transmission?

Mr. Stanford: We were a little unfortunate when we first built the high tension transmission in that the electrolytic lightning arresters had not at that time been fully perfected and we were compelled to install, as the best thing available, a type of lightning arrester which was not nearly so perfect as those now installed. We did occasionally have some trouble although not of a serious nature. Since that time we have put in new equipment of the most modern type and have had no serious trouble from storms. Occasionally we have a flash over a switch, but it is only a few moments' work to put the line into service again. One storm seriously impaired the service. During a sleet storm ice formed on the wires so that some of them at the worst point were an inch in diameter. There was a high wind and we were out of service for more than a half day at the North Lake properties. We were able to keep our other properties working without serious interruption. This was a very unusual condition. In fifteen years' experience through the western part of the United States similar conditions had not occurred, so we simply consider that this was an act of Providence and trust that it will not recur.

MR. ABBOTT: I would like to know from a safety standpoint what provision has been made for grounding one of the cables in case it should break; that is, grounding it before the cable would touch the ground; especially with reference to railroad crossings and where the lines may cross occupied buildings.

MR. STANFORD: It is not our policy at any time to carry the lines over buildings if it is in any way possible to avoid it. The question of railroad crossings has been discussed pro and con by engineers for some years. We have made no provisions for grounding the circuits in case of a break. Standard railroad crossings on all lines is by the use of a stranded copper wire. Stranded cable is used and wherever the line conductors are smaller than No. 2, B. & S. gauge No. 0 is used. Railroad crossing would be the last part of the line which would give way. In the State of Michigan we are governed somewhat by the rulings of the State Railroad Commission and this form of crossing complies with their requirements in every respect.

TITANIFEROUS ORES IN THE BLAST FURNACE—A RECENT EXPERIMENT.

BY DWIGHT E. WOODBRIDGE.*

Near the center of the Adirondack region of New York State is one of the most important deposits of titaniferous magnetic iron ores existing in America. For more than a century various efforts have been made to develop this property and to utilize its ore for iron making. The latest and most pretentious of these attempts has been carried on this year, beginning in February and ending with July, 1914. It is currently reported that this endeavor has cost not far from $300,000. In view of its importance and of the probability that there exist large quantities of gabbro ores of a generally similar character in the Lake Superior region, a brief story of the experiment and a resume of the results attained, may be of interest to the members of the Lake Superior Mining Institute.

While many magnetite iron ores contain titanium, and while it is a frequent constituent of coke ash, the Tahawus deposit of the Adirondacks is so great—possibly several hundred million tons, its mining is so simple—it has little or no cover and is especially suited to quarrying, and its proportion of TiO_2 is so high—ranging from 15 to 20 per cent in the ore—that this experiment was expected to have a most important bearing on the future of the industry.

Lake Sanford, upon the shores of which the Tahawus deposits lie, is in the center of the Adirondacks, in a wilderness that is by wagon road nearly 50 miles from Lake Champlain and the town of Port Henry, where is the 200-ton blast furnace of the Northern Iron Company, in which the experi-

*Mining Engineer, Duluth, Minn.

ment was conducted. The country is of wild and rugged beauty, the tumbled peaks of the Adirondacks surround it on all sides, blue lakes gleam through the dense foliage of maple, beech and pine, trout crowd the streams and red deer people the forests.

Here last autumn a magnetic concentrator was built, for the purpose of extracting a portion of the ilmenite from the magnetite and thus reducing the titanium, which is contained in the ilmenite. The plan was to separate here at the mine and convey by wagon the separated ore to Port Henry. Owing to causes that need no explanation in this brief paper, this attempt was futile and it became necessary to hurry the shipment of 10,000 tons of ore, a small part of which had been put through the concentrator. Roads were built through the forest on which grasshopper traction engines were to travel. This ore finally reached Port Henry and was sent to the Witherbee, Sherman & Co. separators at Mineville for the treatment it had failed to receive at Lake Sanford. It was then brought back to Port Henry for smelting.

For many years the belief has been current that TiO_2 in the blast furnace made the slag relatively infusible, viscous and thick, that this ore would cause the formation of infusible titanium compounds, such as cyano-nitrite of titanium, and that serious furnace scaffolding would result. Excessive fuel consumption was feared, and altogether few furnace men were willing to use these ores.

This experiment began with a mixture of Tahawus and Mineville ores (magnetic concentrates from Witherbee, Sherman & Co.) At first the percentage of Tahawus was slight, but it was increased until at the close the furnace was worked on 5/16 Tahawus to 11/16 Mineville. At no time during the entire run did the furnace scaffold seriously and never was the slag anything but fluid and acidic. Several times during the run the furnace broke through, but as the experiment began on an old lining that could not be examined, and as one of these breaks took place in February, no one can tell whether or not the titanic acid had anything to do with it. At the conclusion of the test the lining in the lower portion of the furnace was gone. It is unfortunate that this work did not start on a new lining so that some knowledge might be had of the effect on a furnace lining of an ore carrying an excessively high acidity—of SiO_2+TiO_2. Amounts of coke consumed were not especially excessive, indeed were lower than was generally anticipated. Flux used was marble refuse from Vermont quarries, and later marble mixed with an impure dolomite.

The class of Tahawus concentrates used during the test was:

	High.	Low.	Average.
Fe	57.05	44.85	54.27
TiO_2	14.90	10.81	13.57
V_2O_3	.404	.395	.401

In addition to these ores those used were Barton Hill, Harmony, New Bed and Old Bed. Barton Hill carried .914 TiO_2, New Bed .69 TiO_2, but neither of these was used in large amounts.

It will readily be seen that any experiment in which the total titanium in the iron charge is that derived from what may be contained in 5/16 of the burden running 13.57 TiO_2, or about 4 per cent. in the charge as a whole, is not especially conclusive as to what may be done with titaniferous ores, because such ores have been successfully reduced many times.

Insofar, therefore, as this work may have been intended to prove the limits of use of such an ore as Tahawus, it was a failure, for it proved nothing. But I suppose it was not so intended. It did prove, of course, that ores running up to 10 to 14 per cent. TiO_2 can be mixed in the charge at least to the extent given, without danger to the furnace or excessive cost in operation. It is unfortunate for iron metallurgy in general that the experiment did not go to the limit, so that metallurgists could tell just how much of a highly titaniferous ore they might use in their charges, and the effect of such use on coke consumption. But it was impossible to get out enough Tahawus ore, even had the company wished to do so.

Iron made from the ores used was not especially high in Ti. In pig iron analyses the highest Ti was .67, and it was found that the higher the silicon the higher the titanium, in other words that the heat of the furnace had a direct bearing on the slagging of titanium acid. A great deal of low-silicon iron was made.

Titaniferous iron ore is usually low phosphorus, and composite analyses of many Tahawus drill holes are as follows:

Fe	SiO_2	P	Al_2O_3	TiO_2	V_2O_3 C_2O_3
50.80	3.40	.004	4.20	20.70	.598
35.30	18.02	.079	5.40	15.33	.371
42.49	10.30	.005	4.60	17.63	.643
51.96	1.55	.002	3.80	20.33	.906

A general ratio of relationship is seen to exist between these analyses. Were it possible to utilize such ore in quantity, it would add materially to the bessemer reserves of the country.

It is evident enough that this ore makes fine iron. In 1834 the pioneers of the region erected Catalan forges and small blast furnaces on Lake Sanford and smelted this ore direct in cold blast, with charcoal fuel, a poor local flux and no other ore for a mixture. They had tremendous difficulties, but they made excellent iron. They did not know the ore carried any deleterious elements, and so could not account for their failures. They piled on the charcoal, made of high grade hard woods, and got iron in their forges and cold blast 40-ft. furnaces. That they could do it is wonderful. I have read, and have before me as I write this short paper, scores of letters written by the projectors of the enterprise at that time, and can but marvel at the undaunted courage, the ability, the mechanical and metallurgical skill they displayed. As to the quality of the iron one letter says: "I have been engaged the past few days in testing our iron in blacksmiths' shops. I took a flat bar and a square one. The flat I bent cold and drove the ends together without fracture. Of this iron I have tried everything in the way of a hard test; horse shoes and horse nails and even pieces hammered down to the size of needles which I twisted around a pipe-stem, and I had large pieces bent square on the angles without any giving or fractures. These tests excited the wonder of the smiths, who declared they had never wrought such iron. One of them said he had worked the Russian and the Livingstone iron—which is considered the best American—and that neither would do what ours would; it was perfect at all heats."

A few weeks ago a bar of this old iron was unearthed near Tahawus. Upon analysis it was found to contain:

Si	.065
Sulphur	.015
Phos	.060

Ti..	.198
V..	.038
Gr. Carbon	.025

Notwithstanding extensive discussions, the work of Rossi and others, operations in England and Canada, and this recent experiment, the possibilities of smelting titaniferous ores in the blast furnace are still undetermined. That such ores have been smelted at many places and times, and that excellent pig iron has been made from them, are well known. It is also known that in many such cases the consumption of fuel has been excessive. In the early days conditions existed which do not hold today. Iron was made in Catalan forges or in blast furnaces of from 2 to 5 tons daily capacity; these were in wooded regions where the cost of charcoal was not an element of supreme importance; labor was inexpensive and pig iron brought $50 to $70 a ton.

Many of those who have followed this experiment at Port Henry have remarked on the fluidity of this titaniferous slag, as unexpected and remarkable. While that may be true, I have wondered if, in this case, "fluidity" is not confounded with "fusibility," which is "something else again." The slags may be fluid by reason of the ability of the various components to enter into solution, one with another; may not they be still difficultly fusible because of the presence of elements or compounds that require excessive heat or an undue proportion of fluxing material? I am no furnaceman, as these remarks may indicate, and merely make a suggestion that enters my mind.

Such concentration as was carried out on this Tahawus ore was magnetic separation, in Ball-Norton machines, such as are in regular use at Mineville. This separation was based on the fact that this ore—like many but not all titaniferous magnetics—is a granular aggregate of magnetite, ilmenite, and gangue. The further fact that the magnetite itself contains some titanium, and the ilmenite has iron as one of its integral constituents, makes magnetic separation a more difficult and wasteful process than it might appear to him who looks on the ore and is able to distinguish, easily, the different character of the two minerals. In many experiments ilmenite grains were isolated and tested as to their magnetic permeability, and were invariably found to be almost non-magnetic.

But, as indicated above, when separation was actually undertaken, the tails ran wastefully high in iron and the heads undesirably high in titanium. The following are results of United States Bureau of Mines separation tests on Tahawus ores:

Average Ore.		Concentrates.		Tails.	
Fe	TiO_2	Fe	TiO_2	Fe	TiO_2
		62.66	4.00	38.86	47.50
		60.43	8.93	45.78	45.23
		60.60	9.66	42.84	32.22
60.58	14.00	63.00	5.25	....	....
		65.02	5.90	....	....
		61.04	11.00	....	....
55.07	19.02	61.23	11.15	32.99	47.20

With such results from careful separation tests it is apparent that little may be expected in ordinary practice except to reduce the titanium at the expense of the iron.

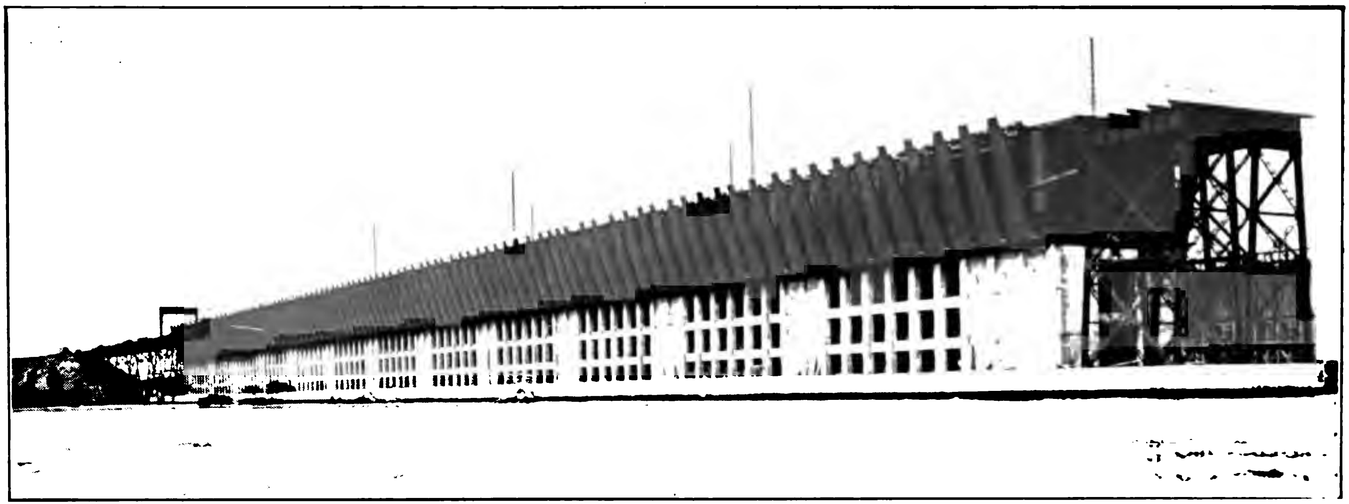
COLLINSVILLE FURNACE NEAR MARQUETTE. (FROM DRAWING IN CHARCOAL BY MRS. PULLMAN, WIFE OF ONE OF THE EMPLOYES WHO CAME TO MARQUETTE ABOUT 1860.) THIS IS THE SITE OF THE PRESENT MARQUETTE CITY LIGHTING PLANT.

LOCKS AT SAULT STE. MARIE—THIS IS THE FIRST LOCK, CONSTRUCTION BEGUN IN 1853, COMPLETED IN 1855.

CLEVELAND ORE DOCK, MARQUETTE, 1873

SCENE ON THE ISHPEMING-MARQUETTE HIGHWAY. TYPICAL OF THE MARQUETTE RANGE

The Ropes Gold Mine. Was Opened in 1882, Continuing in Operation Until 1897. The Mine Produced $647,902.37 in Gold and Silver, About 80 percent of the Product Being Gold. Considerable Gold was Later Recovered from the Tailings and from the Plates.



New L. S. & I. Railway Dock at Marquette. Constructed of Steel and Concrete and has a Capacity of 50,000 Tons. There are 200 Pockets 12 ft. Wide, Which are Reached by Ore Trains From a Steel Approach Trestle 672 ft. Long, Making the Entire Length of the Structure 1872 ft., or 1200 ft. for the Dock Proper. Chutes are 35 ft. Long and Range in Width from 4 to 8 ft. Thirty-four Electric Motors Raise and Lower the Chutes. Dock Contains 6,000 Tons of Steel and 34,000 cu. yds. of Concrete.

Concentrating Plant at the American Mine, Diorite, Mich. (Near Ishpeming)

TIMBER TUNNEL NEGAUNEE MINE—USED FOR CONVEYING TIMBER FROM YARD TO CAGE BELOW COLLAR OF SHAFT

APPROACH TO HILL MINE, OLIVER IRON MINING CO., AT MARBLE, WESTERN END OF MESABA RANGE. (MEETING 1918)

At Wawonowin Golf Club, Ishpeming, Monday. August 31st, 1914

MARQUETTE, MICH., NOVEMBER, 1863. STE. MARIE'S CANAL MINERAL LAND COMPANY'S EXPLORING CREW ENROUTE TO HOUGHTON AFTER THE SUMMER'S WORK IN THE IRON FIELDS.

From Left to Right—(Upper Row)
Rush Livermore, S. S. Curry, John Maroney, Lewis Whitehead, Mose Cheverette, Jacob Schwartz, Charles Griswold.

Lower Row.
J. H. Alward, Henry F. O. D'Aliquy.

Photograph furnished by J. H. Hearding, Duluth, Minn.

MARQUETTE DOCKS AND SHIPPING. ABOUT 1861

MICHIGAN IRON-ORE RESERVES; METHODS OF APPRAISAL FOR TAXATION.

By R. C. Allen, Lansing, Michigan.*

For nearly a half century prior to 1901, the annual production of iron ore in Michigan exceeded that of any other state. Since the year 1900 the production in Minnesota has been greater than that in Michigan, and is now fully two-thirds of the tonnage annually mined in the Lake Superior region and more than half of the total production of the United States. Notwithstanding the overwhelming magnitude of the Minnesota production in recent years, Michigan had shipped at the end of 1913, 40.6 per cent (255,565,856 tons) of the total ore mined in the Lake Superior region.

Permanency of the Iron Mining Industry in Michigan.

Michigan iron mining dates from 1845, when 300 pounds of ore was carried out from the Jackson mine at Negaunee and made into a bar of iron in a blacksmith's forge at Jackson. Twenty years later the annual production was 1,000,000 tons; in 40 years it was more than 2,000,000 tons, and in 60 years, between 11,000,000 and 12,000,000 tons; at the end of 1913 the total production had risen to 255,565,856 long tons.

If all of the openings which were excavated in ore in mining the total production of Michigan were thrown together to form a single void of cubical form, each of its three dimensions would approximate 1,452 feet. The available iron ore reserves of Michigan at the end of 1913 have in the ground in their natural condition a volume of about 2,424,000,000 cu. ft., which is equivalent to a cube whose dimensional index is about 1,343 feet. For each 14 tons of ore mined since 1844, 13 tons still remain in the ground accessible for mining; in other words, the acceleration in production, rapid as it has been, has been fully counter-balanced by acceleration in

*State Geologist of Michigan.

discovery and development. There is now available for mining almost as much ore as has been shipped in all preceding years.

Were exploration and discovery to cease at once, production at the average rate for the 5 years preceding 1914 would exhaust the known reserves in a little more than 17 years; corresponding figures for 1911 and 1913 are 15.2 years and 17.7 years respectively. Up to the present year the reserves have been maintained well in advance of production. Contrary to the popular notion, there seems to be no sufficient reason for believing that this condition will be reversed in the near future, barring of course the possible effect of free foreign competition or legislation unfavorable to mining and development of iron ore. The basis of this opinion rests on, (1) the assured development of large ore reserves at deeper levels than have been attained in mining, (2) expected developments in unexplored and partially explored mineral lands, (3) reopening of abandoned properties, and (4) the future utilization of low-grade ores.

Mining at Deep Levels.

The results of deep-level exploration have in recent years been decidedly reassuring. This is especially true on the Gogebic and Marquette ranges. Large bodies of high-grade ore have been opened under 2,000 ft. in depth on the Gogebic range. The average depth of the mines on this range is now 1,385 feet. Recent drilling on the Marquette range has demonstrated that ore exists, probably in great volume, at depths near 3,000 feet. In Iron county, exploration has not progressed below 1,800 ft., but ore bodies are known to occur near this depth with presumption in favor of still greater depths. Many years will elapse before deep-level exploration will be generally necessary to maintain reserves, for there still remains in drift-covered areas and partially explored parts of easily accessible iron formations, untested possibilities from which new tonnages are being annually developed.

Development of Unexplored Mineral Lands.

At the end of 1913, 71,726,559 tons of ore, equivalent to about one-third of the total reserves, was available for mining in undeveloped properties. The amount of ore which will ultimately be produced from these properties is on the whole much greater than it is possible to measure with assurance in their present condition, although some of them have been so thoroughly developed by drilling that fairly close estimates may be made.

In the following table is given the tonnage of reserves estimated in undeveloped iron properties in Michigan, January 1, 1914, not including prospective ore in developed mines:

	Tons.
Gogebic range	15,610,463
Iron county (Iron River and Crystal Falls District)	35,266,799
Menominee range (Dickinson county)	None
Marquette range (Baraga and Marquette counties)	20,849,297
State of Michigan	71,726,559

In addition to the acreages in which minable ore bodies are known to exist there are 2,392 separate descriptions of land comprising 94,951 acres, wherein there are known possibilities for the occurrence of ore bodies. In the light of present information these lands may be divided into three classes which, in the order of relative probability for ore occurrence, may be denominated, Classes A, B, and C.

Classification of Iron Mineral Lands in Michigan, January 1, 1914.

(Excluding active mines and lands known to be ore-bearing.)

	Number of Descriptions			Acres		
County	Class A.	Class B.	Class C.	Class A.	Class B.	Class C.
Gogebic	71	45	93	2,825.62	1,781.31	3,651.92
Iron	202	29	418	7,673.98	1,200	16,992.25
Dickinson	153	21	221	6,225.16	840	8,924.78
Marquette	666	213	...	27,902.15	6,503.27	....
Menominee	...	...	228	....	....	9,160.75
Delta	...	...	32	....	....	1,270.08
Total	1,092	308	992	44,626.91	10,324.58	39,999.78

A very long time will elapse before the mineral lands are adequately prospected, but the progress of exploration is annually demonstrating that large tonnages in these lands await discovery. They constitute a main source of future production.

Opening of Abandoned Mines.

At the end of 1913 there were no less than 120 abandoned mines that had formerly made ore shipments; 80 iron mines were active and 21 temporarily idle. Of the 65 undeveloped properties containing proven ore bodies 24 were active and 41 were idle. Of the 58 unfinished explorations 19 were in progress and 39 were suspended.

CLASSIFIED NUMBERS OF ACTIVE, IDLE, AND ABANDONED IRON PROPERTIES IN MICHIGAN JANUARY 1, 1914.

	Developed Mines.		Undeveloped—With Proven Ore Bodies		Explorations		Abandoned
Range	Active.	Idle.	Active.	Idle.	Active.	Idle.	Mines.
Gogebic	..23	1	8	4	2	3	13
Iron County	..19	9	11	21	10	20	24
Menominee	...10	4	0	0	1	10	24
Marquette	28	7	5	16	6	6	59
State	..80	21	24	41	19	39	120

The changing condition of the iron trade, gradually decreasing average tenor of shipments from the Lake Superior region, progress in beneficiation of low-grade ores, demonstrated possibilities in deep-level mining, the recurrence of periods of relatively easy finance, not to mention general advances in the science of mining engineering and in geologic knowledge, have made possible from time to time the resumption of activities on properties formerly abandoned. A number of such resumptions have occurred in recent years; some are in progress at the present time, and it is to be expected that a relatively large proportion of the abandoned properties will in the course of time receive thorough exploration by modern methods. Many of the abandoned properties, particularly some of those which were abandoned in early years, will be regenerated. No well-informed person will fail to consider these properties, taken as a whole, as an important source of future production.

UTILIZATION OF LOW-GRADE ORES.

The tonnage estimates which have been referred to above include only those grades of ore which are marketable under current conditions of the iron trade. In commercial practice the definition of iron ore varies from year to year with a well-marked general tendency towards the inclusion of lower and lower grades of iron-bearing rock. For any particular mine the definition of iron ore varies with the sale price of the available grades and cost of production. The grade of iron-bearing rock that may be profitably marketed is not the same in a given year in all districts, nor for all mines in any district. A year of lessened demand or of low prices, such for instance as 1914, always curtails the production of low-grade ore, and invariably forces the suspension of many mines which have only the low grades in reserve. But although demand and price, and consequently the average tenor of the output, fluctuate from year to year, the increasing ratio of iron consumption to available high-grade ore reserves is gradually lowering the tenor of ore marketed from the Lake Superior region. A measure of this tendency is afforded in the following table compiled by W. L. Tinker, secretary of the Lake Superior Iron Ore association:

AVERAGE IRON CONTENT OF LAKE SUPERIOR IRON ORE SHIPMENTS 1902-12, ALL RANGES.

Year	Tonnage.	Average % Iron (Natural.)
1912	44,365,100	51.9603
1911	30,255,438	51.8869
1910	41,172,143	52.0703
1909	40,582,405	52.1130
1908	24,774,568	52.9551
1907	38,574,136	53.4020
1906	36,179,170	53.8652
1905	32,353,475	54.6072
1904	20,529,719	55.5791
1903	22,357,876	55.5049
1902	24,930,701	56.2233

The average yearly decline in iron content for the period 1902-12 is 0.4263 per cent, or 4.263 per cent for the decade. It is obvious of course that this decline must cease at some future period.

There is no doubt that ores of very low grade will eventually have to be mined in the Lake Superior region. Experiments in the beneficiation of the various types of low-grade ores are already under way. From what has been accomplished it begins to be apparent that nearly all types of low-grade ores will eventually be subject to beneficiation at the mines. Wet concentration methods are now in use on a tremendous scale by the Oliver Iron Mining Company near Coleraine, Minn., while other plants are located near Nashwauk, and at the Madrid mine, near Virginia, Minn., and also at the American-Boston mine at Diorite, Mich. In Canada magnetic concentration is operating at the Moose Mountain mine, near Sudbury, and at the Magpie mine on the Michipicoten range low-grade carbonate ore is treated in rotary kilns. A number of other plants are planned on the Lake Superior ranges. (Table "A.")

It is needless to remark that each decline of 1 per cent in the average content of ores mined adds millions of tons to the ore reserves. How far this decline will be forced cannot be foreseen. An issue of immediate and growing concern refers to encroachment of foreign ore into territory which here-

TABLE "B"

IRON MINES OF MICHIGAN—TABLE OF COSTS.

Range	Number of mines 1908-1912.	Number of mines 1909-1913.	Total Tonnage 1908-1912 Sold	Total Tonnage 1908-1912 Shipped	Total Tonnage 1908-1912 Mined	Total Tonnage 1909-1913 Sold	Total Tonnage 1909-1913 Shipped	Total Tonnage 1909-1913 Mined	Total Cost 1908-1912	Total Cost 1909-1718	Cost per ton mined. 1908-12	Cost per ton mined. 1909-13
Marquette	40	39	16,949,856	17,180,239	18,726,104	17,943,337	18,160,754	19,299,746	*$45,905,800 49,358,704	$51,428,569.14	*$2.68 2.63531	$2.58401
Gogebic	28	29	14,446,149	15,738,981	15,880,973‡	16,368,429	16,354,717	16,480,159	*40,090,621 41,317,840	47,037,450.88	*2.75 2.83741	2.86218
Menominee	17	17	7,957,359	7,984,566	8,390,659	8,258,229	8,221,139	8,433,188	*20,869,922 21,063,259	20,752,060.74	*2.50 2.50764	2.47865
Iron River and Crystal Falls	32	33	11,519,398	11,432,037	12,141,815	13,353,799	13,215,389	13,751,488	*25,402,166 28,506,569	31,919,664.20	*2.23 2.34779	2.35158
State	117	118	50,872,762†	52,345,822	55,148,641§	55,923,794	55,952,029	57,964,531	*132,268,509 140,746,392	151,137,734.96	*2.55 2.60362	2.63794

†Does not include (1) Ashland, (2) Volunteer.
‡Total used to obtain cost per ton is 14.790.125.
§Total used to obtain cost per ton is 54.057,793.
*Taken from Report of Appraiser of Mines to Board of State Tax Commissioners, 1913, page 22. These costs do not include costs reported by mines not on operating basis. They represent 96% of total tonnage mined 1908-1912.

TABLE "C"

SHOWING RESULTS OF THREE APPRAISALS.

Range	Total acreage appraised 1914	Previous appraisals 1911	Previous appraisals 1912	Previous appraisals 1913	1914 appraisal Mine	1914 appraisal Ore in stock	Combined value of mine and ore in stock	Total tonnage in mine and in stock Jan. 1, 1914.	Assessed value per ton
Gogebic	5,987 acres	$28,338,100	$27,226,300	$25,849,873	$30,355,700	$4,311,323	$34,667,023	45,785,670	$0.7371
Iron County: (Iron River and Crystal Falls Districts)	7,567 acres	15,018,475	15,359,664	20,978,709	18,769,652	2,506,293	21,275,945	59,468,551	0.3577
Menominee: Dickinson county.	3,585 acres	7,427,500	7,240,625	6,641,925	4,749,120	1,663,883	6,413,003	13,778,283	0.4654
Marquette: Baraga and Marquette counties	8,003 acres	34,745,000	31,270,500*	29,063,714	24,335,904	4,880,235	29,216,139	83,391,451	0.3503
State	25,142 acres	85,529,075	81,097,089	82,534,221	78,210,376	13,361,739	91,572,115	202,424,155	0.4524

*Approximate figure.

TABLE "A"

MICHIGAN IRON ORE RESERVES, JANUARY 1, 1914.

Range	Data of bottom levels. Average depth,	Tot. areas in ore in sq. ft.	Total reserves estimated by appraiser: Developed (tons)	Prospective (tons)	Ore in stock (tons) Jan. 1, 1914.	Apr. 13, 1914.	Total tonnage Jan. 1, 1914, in mine and in stock
Gogebic	1385 ft.	1,228,574	23,765,158	21,113,192	907,520	1,947,820	45,785,870
Iron county: (Iron River and Crystal Falls Districts)	571 ft.	2,954,947	13,337,913	45,045,227	1,085,411	1,571,739	59,468,551
Old Menominee Range: (Dickinson county)	700 ft.	223,458	11,062,700	2,129,950	585,633	942,167	13,778,283
Marquette: (Baraga and Marquette counties)	751 ft.	3,638,861	33,095,467	47,919,718	2,376,266	3,215,717	83,391,451
State	855 ft.	8,045,840	81,261,238	116,208,087	4,954,830	7,677,493	202,424,155

IRON ORE RESERVES OF MICHIGAN.

Range	1911 Developed Tons	1911 Prospective. Tons	1913 Developed Tons	1913 Prospective Tons	1914 Developed Tons	1914 Prospective Tons
Gogebic county	18,296,721	13,308,279	23,813,191	7,754,388	23,765,158	21,113,192
Iron county (Iron River and Crystal Falls Districts)	7,934,687	25,689,155	13,249,683	47,536,233	13,337,913	45,045,227
Menominee (Dickinson county)	9,082,750	2,567,700	9,632,994	3,100,458	11,062,700	2,129,950
Marquette, (Baraga and Marquette counties)	36,228,742	56,473,068	34,692,034	51,529,275	33,095,467	47,919,718
State	71,542,900	98,038,202	81,437,902	109,920,354	81,261,238	116,208,087
Total	169,581,102		191,358,256*		197,469,325**	

*Of date, Jan. 1, 1913, in addition to which there was in stock 4,366,349 tons of ore, making a grand total of 195,724,605 tons.
**Of date, Jan. 1, 1914, in addition to which there was in stock 4,954;830 tons of ore, making a grand total of 202,424,155 tons.
Increase over estimate of preceding year .... 6,699,550 tons

tofore has been tributary to the Lake Superior mines. This question has a bearing on the matter under discussion, but its complexity does not admit of its consideration here. When the time shall come for general utilization of low-grade, iron-bearing rock from the Lake Superior region, the Michigan reserves alone will be ample for the needs of the country for generations. The supply is so enormous that estimates at this time have no significance.

Recent Estimates of Michigan Iron Ore Reserves.

Careful estimates of the iron ore reserves of Michigan are made annually under the direction of the Board of State Tax Commissioners. The first estimate was made in 1911 by C. K. Leith; the estimates for 1913 and 1914 were made by the writer assisted by O. R. Hamilton.

The reserves are divided into two classes, viz: developed ore and prospective ore. The developed ore is that which is expressed by mining engineers by the term "ore in sight," and is limited to ore blocked out above bottom levels in developed mines. The prospective ore is included in undeveloped properties, extensions below bottom levels, and in lateral extensions of partially developed levels.

Inasmuch as each of the three estimates above referred to were made by the use of the same methods the resulting totals may be considered strictly comparable. The managers, superintendents and engineers of the various mines should be credited with the indispensable aid which they rendered in the work of each of these tonnage estimates.

The Cost of Mining Iron Ore in Michigan.

The following table of costs is compiled from the annual reports of the mine operators to the Board of State Tax Commissioners. The two sets of figures represent an average for the 5-year period preceding 1913, and the 5 years preceding 1914, respectively. For the former period there is included only those mines which were on an operating basis representing 96 per cent of the total tonnage mined during the period. The figures for the latter period, however, include total costs for all mines, excluding charges for exploration on undeveloped properties and all capital charges. The figures for both periods include freights and represent the cost of delivery of ore at the sale points, viz: mainly the Lake Erie ports. (Table "B.")

VALUE OF MICHIGAN IRON ORE IN 1913.

The figures annually reported to the Michigan State Tax Commission afford the means of ascertaining the value of Michigan ore at any stage in the process of mining and marketing, from its natural location in the ground to point of delivery. The table herewith shows the calculation of value of Michigan ore by ranges f. o. b. mine in 1913.

TO ASCERTAIN VALUE PER TON OF 1913 IRON ORE SHIPMENTS.

Range	Gross Receipts	"Beyond the Mine" Charges	Net Receipts (f.o.b. at Mine)	1913 Tons	Value per Ton.
Gogebic	$15,960,386.61	$ 4,117,877.71	$11,842,508.90	3,836,739	$3.08
Iron River, Crystal Falls.	8,688,761.74	2,248,845.02	6,439,916.72	3,088,591	2.08
Old Menominee	5,306,965.51	1,227,781.23	4,079,184.28	1,708,847	2.38
Marquette	11,708,799.80	2,687,628.19	9,021,171.61	3,790.566	2.38
State	41,664,913.66	10,282,132.15	31,382,781,51	12,424;743	2.52

ROYALTY AND OWNERSHIP.

The term royalty refers to payment by operators for the ore in properties in which they own a part or none of the mineral value. The royalty is proportionate to the number of tons of ore shipped and is calculated on a flat or a graded rate per ton, or a combination of the two. Nearly all of the modern leases provide for a graded royalty based on sale price of ore, or on its composition. The sum paid for the privilege of holding a lease is called the minimum royalty. The royalty paid by the operators on shipments is commonly charged against the minimum, but in the event that the amount is less than the stipulated minimum royalty, the difference must be paid to the fee owner.

The ownership of more than three-fourths of the Michigan iron mines resides wholly or partially in *fee holders* in distinction from *operators*. In the period 1908 to 1913, 88 per cent. of the producing mines paid royalties. There have been few recent transfers of title to minerals in undeveloped iron lands. Mainly because of the uncertainty of values, both owners and operators prefer to deal with these lands on a royalty basis under the leasing system.

Royalties which were actually paid by producing Michigan mines for the period 1908 to 1913 range from 0.864 cents to 0.055 cents per ton. Average royalties are highest on the Gogebic range; then follows in decreasing order the Marquette, Iron River-Crystal Falls and Menominee ranges. The figures in the table take no account of the partial ownership of minerals by operators of some of the royalty-paying mines, and are consequently somewhat lower than the average royalties expressed in leases. The figures are obtained by dividing the total royalties paid by the total tons shipped, excluding the mines wherein full ownership of minerals is vested in the operator.

ROYALTIES PAID BY MICHIGAN MINES (1909-1913).

Range	No. Producing Mines	No. Shipping Mines Paying Royalty	High	Low	Average per Mine	Average per Ton Mined
Gogebic	26	26	.52723	.22372	.37633	.34765
Iron River, Crystal Falls..	32	32	.54279	.08142	.28393	.23148
Menominee, including Metropolitan & Calumet....	15	15	.36077	.05494	.24198	.23605
Marquette, Gwinn	36	23	.86400	.02766	.44452	.19877
State	109	96	.....	.....	.34105	.25249

MICHIGAN IRON ORE RESERVES BY RANGES IN 1914.

Range	Total Reserves (including ore in stock) Jan. 1 1914. Tons	Controlled by U. S. Steel Corporation. Tons	Per cent.	Controlled by Other Companies. Tons	No. of Other Companies	Per cent.
Gogebic	45,785,870	13,000,664	28.4	32,785,206	10	71.6
Iron county: Iron River and Crystal districts	59,468,551	2,777,455	4.6	56,691,096	26	95.4
Menominee range (Dickinson Co.) ..	13,778,283	5,831,845	42.3	7,946,438	7	57.7
Marquette: Baraga and Marquette counties	83,391,451	24,937,490	29.9	58,453,961	19	70.1
State	202,424,155	46,547,454	22.9	155,876,701	57	77.1

In the 5 years preceding 1914, 109 mines controlled by 64 operating companies including subsidiaries, made shipments; of these 96 paid royalties. The Oliver Iron Mining Company of the United States Steel Corporation is the largest shipper, but does not hold the position of preponderance in Michigan as it does in the Lake Superior region in general, as shown in the table. Of the total reserves in 1914, 46,547,-454 tons, or 22.9 per cent., is controlled by the Oliver Iron

Mining Company, while 155,876,701 tons, or 77.1 per cent., is controlled by 16 other companies. The number of independent companies becomes 57, if the larger organizations are broken up into their subsidiaries.

THE MICHIGAN SYSTEM OF APPRAISAL OF IRON MINES FOR TAXATION.

The following discussion is offered for the general information merely as an exposition and not as an argument:

What has come to be known as the Michigan system of iron-mine appraisals is an outgrowth of the methods introduced by J. R. Finlay in 1911, modified in such manner as the experience of the past 3 years has shown to be advisable. The Finlay appraisal of 1911 demonstrated conclusively that Michigan iron mines, prior to that time, had been assessed, on the whole, for purposes of taxation at figures far below their actual value. The total assessed value was not only too low, but some properties in particular were far under-assessed, while others in comparison were assessed at a much higher proportion of true value.

The first valuation of the iron mines by J. R. Finlay in 1911 demonstrated the wisdom of control over assessments by the central authority of the State Tax Commission. In order to maintain this control, and at the same time do substantial justice to the properties affected, it is necessary to make an annual appraisal, for the reason that the value of mines fluctuates to far greater extent than any other class of real estate. While ore is being taken out of the ground and shipped away, additional ore is being added through discoveries of new properties and progress of developments in the producing mines. Furthermore, the quality of the ore in the different properties is subject to change, as are also the economic or trade conditions of the iron and steel industry, which determine the value of the crude material or iron ore. The fluctuation in total value of all of the mines is of course not reflected in the oftentimes enormous fluctuation in the value of individual properties.

Having determined on the control of iron mine assessments the Board of State Tax Commissioners was confronted with the problem of securing trained assistants, without incurring an expense out of proportion to the benefits to be derived by the state, counties and local assessing districts. Thus originated the plan of co-operation between the Board of State

Tax Commissioners and the Board of Geological Survey under which the State Geologist acts in the advisory capacity of appraiser of mines. The plan was given legal sanction through an appropriation of funds for the purpose by the legislature in its last session.

The final results of the appraisal of iron mines for taxation are determined through the application of four distinct procedures.

First. It is the duty of the State Geologist and his assistant, who is a mining engineer, to secure adequate information on which to base the value of each mining property. To this end he requires to be made by each mine operator an annual report to the Board of State Tax Commissioners, as of date December 31 of the year preceding, comprising: (1) a detailed financial statement of the operations of each mine or mining property owned, operated, or controlled by him, executed on forms especially designed by the appraiser for the purpose, and duly executed before a Notary Public, covering a period of the preceding 5 years. (2) The financial statement is required to be supplemented by a complete set of mine maps showing each mine level, together with cross sections, records of drill holes, pits, shafts, etc.; also a map showing the boundaries of each property and the relation of ore bodies to adjacent properties. All maps, plats, records, etc., as are required are signed, dated and duly executed by the operator or a responsible official of the company, and form a part of the report of the operator to the Board of State Tax Commissioners.

Second. After the receipt of the above information the State Geologist and his assistant make an inspection of the mines above and below ground for the purpose of making calculation of total ore reserves in each property and obtaining such other data as may have a bearing on values.

Third. After the appraiser has calculated the value of each individual property his findings are reported to the Board of State Tax Commissioners who consider, with the appraiser, each of the several properties in detail and take formal action on the figures recommended by the appraiser.

Fourth. The figures which are determined upon by the Board of State Tax Commissioners are then reported to the operators. The operators are then given an opportunity of appearing before the Board of State Tax Commissioners for the purpose of submitting any additional arguments or information having to do with the value of their respective properties. These hearings are conducted in public, usually in the counties in which the properties are located, in order that any other interested party or parties may appear and submit information, arguments, and data having to do with the mine values. At the conclusion of these public hearings the various properties are again considered in detail by the Board of State Tax Commissioners, and final values for assessment purposes are fixed and reported to the local assessors by whom they are placed on the tax rolls.

Theory and Method of Appraisal.

Stated briefly, the value of an iron mine under the Michigan system is the present worth of the sum of money representing the calculated difference between total receipts from sales of ore and the cost of marketing the product based on the entire tonnage which the mine may be expected to produce. This difference exceeds by a large amount the actual profit to operators, for it includes the item of royalties and makes no allowance for sinking general outside exploration charges.

We have now to consider how the total profits, thus defined, expected to be produced by the operation of a mine, may be calculated. The calculation is the product of three factors, viz: (1) total tonnage of available ore; (2) average annual excess per ton of the receipts over actual cost of operation; (3) the present worth of one dollar to be paid in equal annual installments for a period of years equal to the productive life of the mine. It is obvious that the alteration of any one of these factors will alter the result in the same proportion, and the result will approach correctness only in proportion as each factor is given proper numerical value.

1. *The Factor of Tonnage*—There is no general method or set rule for measuring tonnage which may be applied indiscriminately to all iron mines. It is necessary to adapt the method of tonnage estimation to each individual property, because of the wide variation or dissimilarity in the natural or geologic conditions in the various mines and districts. The ore which is expected to be realized is considered under two classes; first, the *ore in sight,* and second, the *prospective ore.* In most of the undeveloped properties much the greater part of the ore must be considered as prospective pending the development by underground mining. The amount of developed ore in the producing mines may be calculated with comparative ease,

but the amount of prospective ore must be determined in the judgment of the appraiser by use of principles of geologic and mining practice. It would not be proper to assess a mine, under ordinary circumstances, on the basis of developed ore alone, inasmuch as it is patent in nearly all of the mines that there are certainties, probabilities and possibilities for the occurrence of ore beyond that which is actually developed. As a matter of actual practice the amount of prospective ore on which the mines are assessed for purposes of taxation exceeds the total amount of developed ore. For instance, on January 1, 1914, there were 81,261,238 tons of developed ore in the mines to which was added by the appraiser 116,208,087 tons of prospective ore. These figures do not include 4,954,830 tons in stock on the same date which is treated as developed ore, but assessed as personalty in distinction from realty. In estimating total reserves in a mining property the appraiser attempts to ascertain the total amount of ore which may reasonably be expected to be produced from the property. In the calculation of values "prospective" and "developed" ore are treated on the same basis, i. e., each ton of reserve ore whether "prospective" or "developed" is considered as a unit of value.

2. *The Factor of Average Annual Profits*—The actual profit per ton mined is ascertained for each particular mine as nearly as possible from its actual operating financial record over a period of 5 years preceding. It is obvious that the value of an iron mine for purposes of taxation should not fluctuate from year to year in harmony with fluctuating costs and ore prices. By the use of the 5-year period large fluctuations in the total valuations on account of sharp annual variations in costs and receipts in individual properties have been eliminated.

It is obvious of course that an undeveloped property has no operating record from which profits may be calculated. For these properties the expectations are measured by the experience of mines under operation under similar conditions in the district in which the undeveloped property is located.

3. *The Life Factor and Interest Rate*—The product of total reserve tonnage in the mine by a calculated profit per ton expected to accrue under operation is in most cases far in excess of the present value of the property, because the rate at which ore can be mined is limited by both physical and market conditions. Only a fraction of the total ore reserves are annually marketed, and the income from operation is there-

fore realized from year to year as the ore is mined and sold. The value of an iron mine resides in the ore, and it follows that when the ore is exhausted, all assets are dissipated, except of course the junk value of the equipment and surface value of the land. An ore body in process of mining is, therefore, a wasting asset, and the valuation of an iron mine involves the determination of the present value of this wasting asset.

The time or life factor must therefore be taken into account. The productive life of an operating mine, for purpose of appraisal, is the ratio of total ore reserves to the average annual shipment which in practice is based on the experience of the preceding 5 years. The life of an undeveloped ore body is measured in the same manner, on the assumption of an average shipment indicated by other developed properties of the same class, with proper allowance and discount for the time necessary for development to the producing stage.

After ascertaining the average annual profit or dividend, and the number of such annual dividends, (which is represented by the number of years of productive life) the total is reduced to present worth by the annuity method, using an interest rate of 6 per cent. for both principal and sinking fund. It has been argued that the sinking fund should bear interest not to exceed 3 or 4 per cent., but in actual practice profits are usually invested and reinvested in the mining business, and treated in exactly the same manner as capital, and for this reason profits are treated in the calculation as capital.

The above methods are applicable in general, but must be modified by such considerations as are pertinent to individual cases. Such modifications are applied in accordance with the judgments of the appraiser and the Board of State Tax Commissioners. It will not be necessary here to explain the multiplicity of cases which demand the application of judgment involving departure from the general method set forth above.

The results of three appraisals are shown in Table "C":

Are the Michigan Iron Mines Assessed at Full Present Value?

Irrespective of methods employed in the assessment the important question refers to whether resulting figures actually represent the true present worth of the iron mines. As bearing on this question there is introduced a statement of the relation of profits, as heretofore defined, to the valuation of the mines:

Valuation of iron mines January 1, 1914, including ore in stock, $91,572,100.

Tonnage: Developed ore, 81,261,238 tons.

Tonnage: Prospective ore, 116,208,087 tons.

Tonnage: In stock, 4,954,830 tons.

Total, 202,424,155 tons.

Total assessed valuation per ton, 45+ cents.

Average annual shipment 1909-1913, 11,863,450 tons.

Life of reserves, 17+ years.

Total average annual receipts over and above costs of production 1909-1913, $11,359,730.

Ratio of total average annual receipts over and above costs to total assessed valuation $0.12 or 12 per cent.

The average annual return of 12 per cent ($11,359,730) on the total valuation ($91,572,100) will return an annual interest of 8 per cent and provide for a sinking fund at 4 per cent with which to replace capital ($91,572,100) in 17.7 years, which represents the life of total reserves of developed and prospective ore in 1914.

Relation Between Sale or Exchange Value of Iron Mines and Assessed Value in Michigan.

Iron mines in Michigan are rarely bought and sold, and we have therefore no safe means of comparison between assessed valuations and exchange values of iron mines in this state. During the past year, however, an instance has come to our attention which is cited as evidence, so far as it goes, of the relation between assessed values and exchange values of Michigan iron mines. The Republic mine located at Republic, Mich., was assessed in 1911 at $942,000; 1913 at $1,040,000; in 1914 at $1,110,299. This mine was sold a few months ago by the Republic Iron Company to the Cleveland-Cliffs Iron Company, including ore in stock, equipment, and more than 4,000 acres of undeveloped lands for $600,000. This sale was urged by the new owners of the mine as an argument in a general contention that the assessed valuation of the Republic mine should be reduced. No reduction was granted by the Board of State Tax Commissioners.

The point of the matter lies in the fact that the purchaser of an iron mine not only expects the return of his investment, but a rate of interest on the same which can not be measured by rates used in ordinary mercantile and industrial transactions.

THE CAVING SYSTEM OF MINING IN LAKE SUPERIOR IRON MINES.

J. PARKE CHANNING.*

The recent statement by me that the late Mr. Joseph Sellwood was responsible for the introduction of the caving system of mining in the Lake Superior iron mines has called forth criticism as to the accuracy of my statement, and it is claimed that this method was first used at the Cleveland Hematite mine, which was a soft ore property lying about half way between Ishpeming and Negaunee.

In 1886, when I went to the Gogebic Range for the first time, the Brotherton mine, near the Village of Wakefield, was being operated by Mr. Joseph Sellwood, he had for the superintendent the late Mr. John Pengilly, who had as his two foremen Mr. John Harris and Mr. Thomas R. Hocking. The mine was wrought on the sub-level system of caving, which I fully described with illustrations in an article entitled Lake Superior Iron Ore, published in Volume III of the Mineral Industry, being for the year 1894. Later on when Mr. Sellwood took charge of the Chandler mine on the Vermilion Range, he transferred Mr. Pengilly to that property, and this mine was wrought on a similar system.

In 1890 I left the Gogebic Range and went to Ishpeming, Michigan, to take charge of the East New York mine, and took with me for mine foreman Mr. Hocking, who had, up to that time, continued as one of the foremen at the Brotherton mine. We changed the method of mining at the East New York from square sets to caving, and at the same time Mr. Thomas F. Cole, who was in charge of the Queen Group of mines at Negaunee, introduced this system at his mines with great success and economy. After coming to reside in Ishpeming I visited all the mines in the district, among them the Cleveland Hematite, and I am quite sure that the caving system was not in use there at that time.

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I have been told that Mr. George W. Wallace, afterward manager of the Fayal mine on the Mesabi Range, introduced the caving system at the Cleveland Hematite at the suggestion of two north of England miners, who had been accustomed to its use at home. If this is so, evidently the experiment was not considered a success, or else at the time of my residence in Ishpeming it would have been in use at the Cleveland Hematite.

It is a well known psychological fact that similar problems are often solved in an identical manner by men who have had no communication with each other. It is said that Wallace was at work on the Origin of Species at the same time as Darwin, and it is interesting to note that Mr. Guy R. Johnson introduced a sub-drift system of mining at Longdale, Va., at the Longdale mine, which was almost identical to that of the Brotherton. This method he described in a paper on page 96, Volume XX, of the Transactions of the American Institute of Mining Engineers for the year 1891, under the title of "Methods of Working and Surveying the Mines of the Longdale Iron Company, Virginia." Mr. Johnson, himself, told me many years ago that he had never heard of the Brotherton use of this system, and if my memory serves me right, he also said that he had not known of it as the North of England system of mining, but that he and his staff worked it out as the best solution of the problem presented them.

Time is passing and a new generation of mining men are coming in. The Lake Superior Mining Institute is becoming a recorder of the history of Lake Superior, and I, as one of its charter members, would welcome any information on this interesting question. Most new inventions and discoveries are 95 per cent. past experience of others and 5 per cent. novelty. He who adds but a little to the world's efficiency deserves credit, and I would be the last one to hold it from him.

DISCUSSION.

MR. YUNGBLUTH: We have a letter from Captain Thomas Walters of the Pittsburgh & Lake Angeline Iron Co., at Ishpeming, regarding his experiences with the caving system, which will be published.

From my own experiences at the Cleveland Hematite mine, I know that the caving system was started, in some of the stopes, in 1884. As I left there in 1885 I cannot say whether the system had been changed at the time that Mr. Channing visited the mine after coming to Ishpeming in 1890.

We shall endeavor to bring out as much information on this subject as possible, and I would be pleased to hear from the members present who have had any experience or information regarding the caving system.

MR. JEWELL: I was working for the Oliver company and when Captain Walters got back from the North of England, where we worked the same system, we all left and went to work for the Lake Angeline and I think that was about the first time the system was started in this part of the country. We worked that system in England before coming to this country in 1888—about four years before or 1884.

MR. PASCOE: I never had any experience in soft ore mines. I should judge it was in the eighties sometime that they adopted that method of mining.

MR. KEESE: My first experience along the caving system of mining was in the old Florence mine in Florence, Wisconsin, in 1889. There was a little of that work carried on at that time. Since then it has been carried on more or less on the different ranges where this system would work. Further than that, I have had no experience with the caving system.

MR. JOPLING: The matter of introducing the caving system in the iron mines of the Marquette Range is one of which I have some recollection. As to Captain Walters, it is more particularly fixed in my mind because we both returned to England for a visit during the same year, namely, 1887. Mr. Walter Fitch accompanied Captain Walters to the North of England where they investigated the caving system in use in the Lancashire district. I cannot say just when Captain Walters introduced the caving system into the different mines with which he was connected but I am sure that it was soon after his return in 1888, even if he had not previously worked under this system.

The following is an extract from a letter written by Captain George W. Wallace, dated San Francisco, March 25, 1914. It was written in answer to my inquiry whether he did not use this method at the Cleveland Hematite mine, where he was in charge when I first met him in 1882.

"Now as to your question about the caving system: Yes, I think I was the first one in the United States that used the method, having secured the ideas from two miners from Dalton-In-Furness, Lancashire,

England, where the method was extensively practiced, we modifying the system somewhat to meet our requirements. It proved so satisfactory, and was such an improvement over square setting for soft ore mining, that most every one in the soft ore mining business readily recognized it and it was only a short time before a great many mining men of different districts made claim that they were the originators.

"I wrote up the whole system about four years ago, describing in detail everything as completely as I possibly could, and believe me it is quite a long story and I am very sorry to say that moving West the manuscript got lost and I do not think I could write it all again without a good deal of trouble, and then too, the photographs and cuts were lost and I am sure I could not secure others. Otherwise I should like very much to give you the story for publication."

You will note that Captain Wallace does not state the year in which he first used the method but from a letter written by Mr. D. H. Bacon this method was adopted in some of the stopes of the Cleveland Hematite mine shortly after the company took it back from the lessees, which was in 1881. It is to be regretted that Captain Wallace's article was lost at the time he moved away from Lake Superior.

You will see from my recollections that Mr. Channing can hardly be right in claiming the first use of this system in Lake Superior in 1889.

MR. EATON: I have talked this matter over with Captain Collick. Captain Collick is one of our oldest employes and is one of the oldest men who worked this caving system. He has been captain of the Lake mine since 1896 and before that worked at the Hematite mine, and he said the system was in use in part of the Hematite mine before he was captain there, when he had a contract sinking a shaft.

MR. JOHNSTON: I know that Mr. Cole introduced it in the Queen mines while he was there and got such excellent results that it was talked of a good deal. It cheapened the cost of mining the ore very much, but I cannot tell you just what year it was introduced there. It was while he was agent of the mines for the Schlesingers or Corrigan-McKinney & Company.

MR. YUNGBLUTH: I took this matter up with Mr. Bacon in the early spring. I had in mind a paper to treat this subject and for that reason had written to Mr. Bacon. The claim is made that the caving system was worked at the Cleveland Hematite mine in 1884. Captain Collick, whom Mr. Eaton mentioned, was at that time a miner at the Cleveland Hematite mine and I talked with him the other day and his recollection of the matter was quite clear; that it was worked at the Cleveland Hematite mine before he became mining captain and during the time that George Wallace was captain. Wallace left the Cleveland Hematite in 1887.

MR. CORY: I will say that Captain Collick had charge of the Hematite mine in 1888 and I worked for him there in 1890. We had the caving system in use pretty generally at that time.

Extracts taken from a letter written by Captain Thomas Walters of Ishpeming, dated August 31, 1914, in regard to the first mining operations by the caving system.

"Mr. Channing is somewhat in error in reference to the underground mining and caving system. The underground square set system was started in 1877 in the Mitchell mine and this system was carried on very successfully for a small property, and possibly one of the first hematite mines of the underground system on Lake Superior that operated at a profit. This was continued until 1882.

"In early 1883, I took charge of the opening of the Lake Angeline mine, which gave me a better opportunity to work out various systems. Having about 86 feet of surface over-burden, I started the square set system in this mine. After working out the stope about fifty feet, I then put raises to the surface and used the over-burden and rock from the mine to fill these stopes, before taking the pillars, and this worked very satisfactorily and we mined this out at a fair profit to the stockholders. However, on account of the character of the ore in this body, it was hard to separate the Bessemer from the Non-Bessemer in this system of operation, and about 1885 or the spring of 1886, I changed the system and started what is now universally known as the slicing system. I found there was a little higher cost attached to this system on account of all the ore being handled with shovel, whereas in the square set system we used to run it into the cars as it accumulated on top of the sets, but I was able to make a very satisfactory separation from this system of operation, raising to the top of the ore, or close to the 'gob' from the main level. I put a crosscut in each raise and took samples every foot and after the crosscuts were in we made diagrams showing where the Bessemer and Non-Bessemer ore lay.

"This method was very successful and increased our Bessemer ore at least 20 per cent. over what we were getting with the square set system, and aside from this, it reduced our accidents to the minimum. We have been working this system constantly at Lake Angeline and lately at the most hazardous work of all—taking out the pillars—and it is all of ten years since we have had a fatal accident underground in this mine.

"I was very much criticised when I started the slicing system, but as time went on we began to make some money and it is now a universal system in underground iron ore mines. I am sure it has reduced the accidents, both minor and fatal, to the very low minimum we have today in comparison to the accidents with the square set system as, when the sets were three or four high, the men would sometimes fall as the caps would become very slippery and they would neglect to take plank to walk on.

"The slicing system, then, has two very high points of merit, one being the lessening of accidents and making the work less hazardous for the operators, and the fact that it enables the operator to separate or classify the ores.

"As to the late Mr. Sellwood, mentioned in Mr. Channing's paper, he had not started on the mines Mr. Channing speaks of at that time, nor had Mr. Pengilly; both these gentlemen being warm friends of mine."

The following is an extract of letter received from Mr. D. H. Bacon, New York City, under date of September 8th, 1914, on the caving system at the Cleveland Hematite mine .

"Early in 1881 Robert Nelson surrendered his lease of the Nelson or Cleveland Hematite mine near Ishpeming, to the fee owners, namely: the Cleveland Iron Mining Company, and thereafter until all of the ore had been removed (1893), the mine was under the care of the operating staff of this company, whose mines were then and until July, 1887, under my care. Mr. Nelson had removed nearly all of the ore that could be safely taken from open pits. As soon as we began underground work our troubles began; the ore was very soft and would scarcely stand vertically in the side of a drift; the footwall would barely sustain itself and the hanging resembled a pile of loose bricks. Stulls were tried, but we found every foot of the hanging must be laced, making the laying of the stull pieces on the ores necessary. With square sets, then known as the 'Nevada System,' we had but little success. With each method the cost per ton far exceeded its market value. Two men who were employed at the mine described a method of timbering that they had seen in use in an English mine and, although the conditions were unlike, we decided to give the English method a trial. It proved a success and the system was followed as long as I was with the company and I believe was continued by my successor, Mr. F. P. Mills, until the mine was abandoned. One of the first mines opened on the Gogebic Range was the 'Brotherton,' and the writer was asked to engage some one to take charge of the mining. I, therefore, sent John Pengilly from No. 3 Hard ore mine of the Cleveland, to the Cleveland Hematite to learn the caving method; then I put him in charge of the 'Brotherton.' It may have been two years later that I put him in charge of the explorations that were being made by the Chicago & Minnesota Ore Co., on the Vermilion range, in Minnesota. Mr. Pengilly found what was later known as the Chandler mine, and in the mining followed

the system of timbering that he had learned at the Cleveland Hematite under Mr. George W. Wallace. With the mining methods in use on the Marquette and Menominee ranges, Mr. Wallace and myself were familiar, and we are satisfied that the caving method was not in use in any Lake Superior iron mine at the time it was tried at the Cleveland Hematite."

SUMMARY.

(From the above discussion and quotations from letters, it appears conclusively proved that the caving system was adopted at the mines on the Marquette Range previous to 1887).

LIST OF IRON MINING PROPERTIES OF MICHIGAN AND WISCONSIN.

COMPILED BY CARL BREWER, ISHPEMING, MICH.*

The accompanying lists of mining properties on the Marquette, Menominee and Gogebic Ranges contain nearly all the properties that have been credited with iron ore shipments, or whereon are known ore deposits. The lists are in alphabetical order according to ranges. The information regarding the various properties includes the government land description; other names, if any; names of present operators and sales agents, where the properties are either operating, temporarily closed or are reserves; and an indication of the present condition. In giving the government land description, great latitude has been necessary because of the difficulty of defining what is meant by "description." I have endeavored to use the following rule in compiling the lists. The location of abandoned mines are the forty acre tract or tracts, whereon the actual mining was done. The reserves are described according to the territory included in the tax lists. The other properties are described according either to the limits of the mining lease, to the forties considered by the operators as pertaining to the mine, or in the case of fee ownership, where the boundaries are not too extended, to the forties so owned. Lack of definite information makes it impossible to indicate these distinctions.

Properties in Wisconsin are so described, all others are in Michigan. In the column for remarks are given whatever names a property may have had; the present operating company and sales agents. All the names under which any property has made shipments are listed in their place and reference is made to its other names. Where no operators or agents are mentioned, it indicates that the property has been abandoned as a mine. In the last column are dates either of last shipments or when name was changed, or the letters "D," "P," "U." "D" indicates that the property is being developed, no ore having as yet been shipped. "P" indicates that ore has

*Of Engineering Staff. The Cleveland-Cliffs Iron Co.

been shipped during 1914. "U" indicates that the property contains ore reserves upon which no mining operations have been done. The presence of a date in the last column and the name of operating company indicate that the property is only temporarily closed. The names of the sales agents are enclosed in brackets.

Any correction or addition is earnestly requested. I wish to thank all those who have aided me in compiling these lists.

MARQUETTE RANGE.

Properties marked "B" are situated in Baraga county, all others in Marquette county.

Property	Sec	T	R	Description	Operating Company (Sales Agents)
Albion	19	47	27	ne¼ of nw¼	1879
Allen	8	47	26	se¼ of nw¼	Now part of Mary Charlotte 1874
American	32	48	28	w½ of sw¼	Formerly Sterling. American-Boston Mining Co. (M. A. Hanna & Co.) .... P
Ames	2	47	27	se¼ of sw¼	1894
Argyle	2	47	29	sw¼ of se¼, se¼ of sw¼	Formerly Edwards, now Sampson 1883
Athens	6 5	47 47	26 26	part of se¼ part of nw¼ of sw¼	Athens Mining Co. (Cleveland-Cliffs Iron Co.) .... D
Austin	20	45	25	n½ of sw¼	Cleveland Cliffs Iron Co. P
Barasa	32	48	26	sw¼ of se¼	1902
Barnum	9	47	27	s½ of ne¼	Now part of Cliffs Shaft 1891
Barron	11	47	29	s½ of nw¼	Washington Iron Co. (E. N. Breitung & Co.) ... P
Bay State	8	47	26	w½ of nw¼	Formerly Green Bay, Indiana, part now in Mary Charlotte 1883
B Beaufort	22	48	31	nw¼ of sw¼	1911
Bessemer	35	48	27	sw¼ of se¼	Now Lillie 1884
Bessie	35	48	29	ne¼ of sw¼	1906
Blue	5	47	26	part of s½ of sw¼	Oliver Iron Mining Co.. P
Boston	32	48	28	se¼ of sw¼, sw¼ of se¼	American-Boston Mining Co. (M. A. Hanna & Co.) .... P
Braastad	21	47	27	sw¼, w½ of se¼	Now Winthrop and Mitchell 1899
Breitung Hematite	6	47	26	part of s½ of se¼ se¼ of sw¼	Breitung Hemaite Mining Co. (E. N. Breitung & Co.) .... P

Property	Sec	T	R	Description	Operating Company (Sales Agents)	
Buffalo	5	47	26	nw¼ of se¼		1901
Bunker Hill	6	47	26	part of ne¼ of sw¼, part of nw¼ of se¼	Cleveland-Cliffs Iron Co.	U
Cambria	35	48	27	lot 8, se¼ of se¼	Republic Iron & Steel Co. (M. A. Hanna Co.)	P
	36	48	27	w½ of lot 5		
Carr	33	47	26	nw¼		1874
Cascade	30	47	26	se¼	Same as Palmer, formerly Howe, now in Volunteer	1894
Champion	31	48	29	s½	Oliver Iron Mining Co.	1910
Chase	3	47	28	ne¼	Cleveland-Cliffs Iron Co.	P
Cheshire	18	45	25	se¼	Now part of Princeton No. 1	1898
Chester	7	47	26	s½ of ne¼	Formerly and later Rolling Mill	1903
Chicago	7	47	26	s½ of se¼		1883
Cleveland	10	47	27	e½ of ne¼	Part now in Cliffs Shaft and Moro	1898
	11	47	27	nw¼ of nw¼		
Cleveland Hematite	2	47	27	nw¼		1895
Cliffs Shaft	3	47	27	sw¼ of se¼, part of sw¼ of sw¼	Part formerly Barnum and part formerly Cleveland. Cleveland-Cliffs Iron Co.	P
	4	47	27	s½ of se¼		
	9	47	27	n½		
	10	47	27	n½ of n½		
Columbia	6	46	29	lot 4	Formerly Kloman	1883
Conrad	7	47	28	sw¼ of sw¼	Formerly Michigan	1880
	18	47	28	nw¼ of nw¼		
Consolidated	28	47	26	s½ of se¼	Formerly Gribben, Mesabe Friend, now Moore	1897
Dalliba	29	48	29	s½ of nw¼, n½ of sw¼	Now Phoenix	1883
Davis	7	47	26	sw¼ of nw¼	Formerly Grand Rapids, Wheeling	1913
Delaware and Lackawanna	5	47	26	ne¼ of se¼	Formerly Sam Mitchell, Section 5, East Buffalo	1888
Detroit	3	47	27	ne¼ of ne¼		1890
Dexter	3	47	28	e½ of nw¼, w½ of ne¼		1897
Dey	3	47	28	w½ of ne¼	Now part of Chase	1884
East Buffalo	5	47	26	ne¼ of se¼	Formerly Sam Mitchell, Section 5, now Delaware & Lackawanna.	1887
East Champion	32	48	29	se¼ of sw¼	Formerly Keystone	1889
East Hill	12	47	29	n½ of nw¼		1875
East Jackson	6	47	26	nw¼ of sw¼	Formerly Pendill, now part of Lucy	1893

Property	Sec	T	R	Description	Operating Company (Sales Agents)	
East New York	2	47	27	sw¼ of sw¼		1905
Edwards	2	47	29	sw¼ of se¼, se¼ of sw¼	Later Argyle, now Sampson	1880
Empire	19	47	26	e½ of sw¼	Empire Iron Co. (Oglebay, Norton & Co.)	P
Erie	28	47	30	ne¼ of nw¼		1883
Etna	7	47	26	ne¼ of nw¼	Formerly part of Manganese	1883
Eureka	11	47	29	nw¼ of sw¼	Same as Peck, Hungerford and Harlow	1873
Excelsior	6	47	27	se¼ of se¼		1879
Fitch	24	47	28	sw¼ of ne¼		1895
Forest City	35	48	27	lot 6, se¼ of sw¼		1881
Foster	22	47	27	se¼ of se¼		
	23	47	27	sw¼ of sw¼		1898
Foxdale	10	47	29	e½ of ne¼		1905
Francis	27	45	25	sw¼ of nw¼, sw¼	Cleveland-Cliffs Iron Co.	U
Gardner	2	44	25	nw¼ of ne¼		
	35	45	25	se¼ of se¼	Cleveland-Cliffs Iron Co.	D
Gibson	29	48	29	n½ of se¼		1887
Gilmore	26	47	26	nw¼ of ne¼, ne¼ of nw¼		1879
Goodrich	19	47	27	w½ of nw¼		1882
Grand Central	6	47	26	se¼ of sw¼	Later Iron Valley, New York Hematite, now part of Breitung Hematite	1878
Grand Rapids	7	47	26	sw¼ of nw¼	Later Wheeling, now Davis	1895
Green Bay	8	47	26	w½ of nw¼	Later Indiana, Bay State, part now in Mary Charlotte	1873
Gribben	28	47	26	s½ of se¼	Later Mesabi Friend, Consolidated, now Moore	1873
Gwinn	28	45	25	nw¼	Cleveland-Cliffs Iron Co.	P
Hartford	36	48	27	e½ of lot 5, lots 6 and 7	Republic Iron & Steel Co. (M. A. Hanna & Co.)	P
Himrod	7	47	26	n½ of se¼	Later Orion	1873
Home	29	47	26	se¼	Same as Prout, later Wheat, now Star West	1879
Hortense	29	48	29	e½ of ne¼		1890
Howe	30	47	26	se¼	Later Cascade, Palmer, now part in Volunteer	1885
Howell-Hoppock	28	47	27	nw¼ of ne¼		1874
Humboldt	11	47	29	n½ of n½	Washington Iron Co. (E. N. Breitung Co.)	1896
Hungerford and Harlow	11	47	29	nw¼ of sw¼	Same as Eureka, Peck.	1873

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
B	Imperial	25	48	31	nw¼	Formerly Wetmore. (Cleveland-Cliffs Iron Co.)	1912
	Indiana	8	47	26	w½ of nw¼	Formerly Green Bay, later Bay State, part now in Mary Charlotte	1879
	Iron Cliffs	12	47	27	ne¼ of ne¼	Same as Section 12....	1882
	Iron Mountain	14	47	27	lot 5	Now part of Iron Mountain Lake	1875
	Iron Mountain Lake	14	47	27	sw¼	Jones & Laughlin Ore Co..	D
	Iron Valley	6	47	26	se¼ of sw¼	Formerly Grand Central, New York Hematite, now part of Breitung Hematite	1892
	Isabella	29	47	26	s½ of sw¼	Cascade Mining Co....	D
	Jackson	1	47	27	entire	Cleveland-Cliffs Iron Co.	P
	Jopling	28	45	25	nw¼ of ne¼	Cleveland Cliffs Iron Co.	U
	Keystone	32	48	29	se¼ of sw¼	Now East Champion...	1880
	Kloman	6	46	29	lot 4	Now Columbia	1875
	Lake	10	47	27	se¼	Cleveland-Cliffs Iron Co.	P
	Lake Angeline	15	47	27	n½ of n½, se¼ of ne¼	Pittsburg & Lake Angeline Iron Co. (Jones & Laughlin Ore Co.).	P
	Lake Superior Hard Ore	9	47	27	n½ of se¼		
		10	47	27	s½ of nw¼, w½ of nw¼ of sw¼	Oliver Iron Mining Co..	P
	Lake Superior Hematite	10	47	27	s½ of sw¼, ne¼ of sw¼, e½ of nw¼ of sw¼	Oliver Iron Mining Co..	P
	Lillie	35	48	27	sw¼ of se¼	Formerly Bessemer. Republic Iron & Steel Co. (M. A. Hanna & Co.)	P
	Lowthian	20	47	27	e½ of ne¼		1883
	Lloyd	6	47	27	sw¼ of nw¼, n½ of s½	Cleveland-Cliffs Iron Co.	P
	Lucky Star	5	47	26	part of sw¼	Breitung Hematite Mining Co. (E. N. Breitung & Co.).........	D
		6	47	26	part of se¼		
	Lucy	6	47	26	w½ of sw¼	Part formerly Pendill, East Jackson, McComber. Cleveland-Cliffs Iron Co........	1912
		7	47	26	nw¼ of nw¼		
	Maas	31	48	26	part of s½		
		6	47	26	part of n½	Cleveland-Cliffs Iron Co.	P
	Mackinaw	35	45	25	n½ of se¼, sw¼ of se¼	Cleveland-Cliffs Iron Co.	D
	Magnetic	20	47	30	sw¼ of nw¼		1881

Property	Sec	T	R	Description	Operating Company (Sales Agents)	
Manganese	7	47	26	n½ of ne¼, ne¼ of nw¼	Part now Etna	
Marquette					Picked from old rock dumps, probably near Winthrop	1892
Mary Charlotte	8	47	26	s½ of nw¼, n½ of sw¼	Part formerly Allen, part formerly part of Bay State, Indiana, Green Bay. Mary Charlotte Mining Co. (E. N. Breitung & Co.)	P
McComber	6	47	26	sw¼ of sw¼		
	7	47	26	nw¼ of nw¼	Now part of Lucy	1883
Metropolis	2	46	30	se¼ of ne¼, ne¼ of se¼	Same as North Republic	1888
Mesabe Friend	28	47	26	s½ of se¼	Formerly Gribben, later Consolidated. now Moore	1896
Mexican	33	47	26	ne¼ of nw¼	Now part of Carr	1873
Michigamme	19	48	30	s½		
	20	48	30	lot 5		1900
Michigan	7	47	28	sw¼ of sw¼		
	18	47	28	nw¼ of nw¼	Later Conrad	1873
Miller	21	47	27	n½ of nw¼		1874
Milwaukee	7	47	26	se¼ of nw¼		1913
Mitchell	21	47	27	w½ of se¼	Formerly Shenango. Pittsburg & Lake Angeline Iron Co. (Jones & Laughlin Ore Co)	P
Moore	28	47	26	s½ of se¼	Formerly Gribben, Mesabi Friend Consolidated	1904
Moro	10	47	27	s½ of ne¼	Part formerly in Cleveland. (Cleveland-Cliffs Iron Co.	1913
Morris	1	47	28	n½ of s½, se¼ of ne¼	Cleveland-Cliffs Iron Co.	P
National	16	47	27	se¼		1884
Negaunee	5	47	26	part of nw¼		
	6	47	26	part of e½ of ne¼		
	32	48	26	part of sw¼	Cleveland-Cliffs Iron Co.	P
New Burt	19	47	27	ne¼ of ne¼		1882
New England	20	47	27	nw¼ of nw¼		1873
New York	3	47	27	se¼ of se¼		1900
New York Hematite	6	47	26	se¼ of sw¼	Formerly Grand Central, later Iron Valley, now part of Breitung Hematite	1882
Nonpareil	5	47	27	nw¼ of nw¼	Formerly St. Lawrence.	1887
North Champion	28	49	29	s½ of nw¼		
North Republic	2	46	30	se¼ of ne¼, ne¼ of se¼	Same as Metropolis	1888

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
	Northwest Republic	19	47	30	n½ of se¼		1892
B	Norwood	22	48	31	s½ of sw¼		1888
	Ogden	13	47	27	sw¼ of sw¼		1897
B	Ohio	22	48	31	s½ of se¼	Niagara Iron Mining Co. (Rogers, Brown Iron Co.)	1912
	Orion	7	47	26	n½ of se¼	Formerly Himrod	1879
B	Orleans	23	48	31	e½	Same as Stewart	1878
	Palmer	30	47	26	se¼	Same as Cascade, formerly Howe, now part in Volunteer	1894
	Parsons	16	47	27	sw¼		1873
	Pascoe	29	48	29	w½ of ne¼		1886
	Peck	11	47	29	nw¼ of sw¼	Same as Eureka, Hungerford and Harlow	1873
	Pendill	6	47	26	nw¼ of sw¼	Later East Jackson, now part of Lucy	1884
	Phoenix	29	48	29	s½ of nw¼, n½ of sw¼	Formerly Dalliba	1887
	Pioneer	4	47	26	nw¼ of sw¼		1888
	Platt	32	47	26	nw¼ of ne¼		1896
	Pontiac	12	47	27	nw¼ of ne¼		1895
B	Portland	26	48	31	n½ of nw¼	Niagara Iron Mining Co. (Rogers, Brown Iron Co.)	1910
	Primrose Valley	28	47	26	se¼ of sw¼		1896
	Prince of Wales	5	47	26	part of ne¼ of sw¼	Oliver Iron Mining Co.	P
	Princeton No. 1	18	45	25	se¼	Part formerly Cheshire.	
		19	45	25	ne¼ of ne¼	Cleveland-Cliffs Iron Co.	1912
	Princeton No. 2	20	45	25	nw¼	Cleveland-Cliffs Iron Co.	P
	Prout	29	47	26	se¼	Same as Home, later Wheat, now Star West	1879
	Queen	5	47	26	part of se¼ of sw¼	Oliver Iron Mining Co.	P
	Race Track	6	47	26	part of n½ of ne¼		
		31	48	26	part of s½ of se¼	Oliver Iron Mining Co.	U
	Republic	7	46	29	e½, sw¼, nw¼ of nw¼	Cleveland-Cliffs Iron Co.	P
	Richards	33	47	26	nw¼ of ne¼		1887
	Richmond	28	47	26	sw¼ of sw¼	Richmond Ore Co. (M. A. Hanna & Co.)	P
	Riverside	35	47	30	lots 1, 2		1893
	Rowland	17	47	26	nw¼ of sw¼		1877
	Rolling Mill	7	47	26	s½ of ne¼	Once Chester, Jones & Laughlin Ore Co.	P
	Saginaw	19	47	27	nw¼ of ne¼		1884

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
	Salisbury 15		47	27	s½ of nw¼, sw¼ of ne¼	Cleveland-Cliffs Iron Co.	P
	Sam Mitchell Section 5 5		47	26	ne¼ of se¼	Later East Buffalo, now Delaware & Lackawanna	1886
	Sampson 2		47	29	sw¼ of se¼, se¼ of sw¼	Formerly Argyle, Edwards	1892
	Schadt					Etna? or Manganese?..	1895
	Section 12 12		47	27	ne¼ of ne¼	Same as Iron Cliffs....	1882
	Section 16 9		47	27	se¼ of se¼		
		16	47	27	e½ of ne¼, nw¼ of ne¼	Oliver Iron Mining Co..	P
	Section 21 21		47	27	w½ of ne¼, s½ of nw¼	Oliver Iron Mining Co..	1913
	Shenango 21		47	27	w½ of se¼	Now Mitchell	1877
	South Buffalo 5		47	26	sw¼ of se¼		1895
B	Spurr 24		48	31	s½ of nw¼, n½ of sw¼		1886
	Star West 29		47	26	se¼	Formerly Home, Prout, Wheat	1900
	Stegmiller 17		45	25	lots 5, 6	Oliver Iron Mining Co..	P
	St. Lawrence 5		47	27	nw¼ of nw¼	Now Nonpareil	1883
	Stephenson 20		45	25	s½ of sw¼	Cleveland-Cliffs Iron Co.	P
	Sterling 32		48	28	w½ of sw¼	Now American	1886
B	Stewart 23		48	31	e½	Same as Orleans	1878
	Swanzy 18		45	25	sw¼ of ne¼		1887
B	Taylor 9		49	33	ne¼ of nw¼		1883
	Tilden 23		47	27	sw¼ of se¼		
		26	47	27	nw¼ of ne¼		1902
B	Titan 21		48	31	lot 1		1887
	Volunteer 30		47	26	w½ of nw¼	Volunteer Ore Co. (M. A. Hanna & Co.).....	P
	Volunteer 30		47	26	s½ of s½	Parts formerly Howe, Palmer, Cascade, West End	1904
		31	47	26	n½ of n½		
	Washington					Included in Barron, East Hill and Humboldt	
B	Webster 26		48	31	n½ of ne¼, se¼ of ne¼		1900
	West End 31		47	26	n½ of nw¼	Now in Volunteer......	
	West Republic 7		46	29	lots 4, 6	Now part of Republic..	1887
B	Wetmore 25		48	31	nw¼	Now Imperial	1889
	Wheat 29		47	26	se¼	Formerly Howe, Prout, now Star West......	1895
	Wheeling 7		47	26	sw¼ of nw¼	Formerly Grand Rapids, now Davis	1887
	Wicks 32		47	26	nw¼ of ne¼	Now Platt	1882
	Winthrop 21		47	27	sw¼	Oliver Iron Mining Co..	1903

MENOMINEE RANGE.

Properties in Dickinson county are marked "D"; in Florence county, Wisconsin "F"; in Iron county "I." Dickinson and Iron counties are in Michigan.

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
I	Alpha	12	42	33	sw¼ of sw¼		1890
I	Amasa Porter	22	44	33	e½ of ne¼	Nevada Land Co.	D
D	Appleton	7	39	28	ne¼ of sw¼	Formerly Sturgeon River	1895
D	Aragon	8	39	29	ne¼, ne¼ of nw¼	Part formerly Harrison. Oliver Iron Mining Co.	P
		9	39	29	n½ of nw¼		
I	Arenson	23	43	35	e½ of nw¼ of se¼	Republic Iron & Steel Co.	U
I	Armenia	23	43	32	e½ of se¼	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.)	1914
F	Badger (Wis.)	34	40	18E	se¼ of se¼		1900
I	Baker	31	43	34	s½ of sw¼	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.)	P
I	Balkan	13	42	33	5 acres in se¼ of nw¼, ne¼, ne¼ of nw¼	Part formerly Mastodon. Balkan Mining Co. (Pickands, Mather & Co.)	P
I	Baltic	7	42	34	w½ of w½	Verona Mining Co. (Pickands, Mather & Co.)	P
I	Bates	19	43	34	nw¼	Bates Iron Co. (M. A. Hanna & Co.)	P
I	Bengal	36	43	35	n½ of se¼	Verona Mining Co. (Pickands, Mather & Co.)	P
I	Berkshire	6	42	34	nw¼ of sw¼, sw¼ of nw¼	Brule Mining Co. (Oglebay, Norton & Co.)	1913
I	Beta	26	43	35	ne¼ of sw¼		1891
I	Blair	29	43	34	sw¼	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.)	U
D	Breen	22	39	28	nw¼ of ne¼, n½ of nw¼	Mineral Mining Co.	1907
D	Brier Hill	9	39	29	s½ of nw¼	Now in Penn Group; connected with West Vulcan, 1892	
I	Bristol	19	43	32	e½ of se¼	Formerly Claire. Bristol Mining Co. (Oglebay, Norton & Co.)	P
F	Buckeye (Wis.)	33	40	18E	s½ of se¼	Reserve Mining Co. (Oglebay, Norton & Co.)	P
I	Buckholtz	27	43	35	ne¼ of se¼	Enterprise Mining Co.	D
D	Calumet	8	41	28	se¼ of nw¼, sw¼ of ne¼		1884
I	Carpenter	31	43	32	n½ of sw¼	Hollister Mining Co. (M. A. Hanna & Co.)	P

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
I	Carpenter	13	42	33	sw¼ of nw¼	Nevada Land Co.......	U
I	Caspian	1	42	35	ne¼	Verona Mining Co. (Pickands, Mather & Co.)	P
D	Central Vulcan	10	39	29	part of entire section	Now in Penn Group; east part connected with East Vulcan, 1892	
D	Chapin	30	40	30	sw¼, sw¼ of se¼	Part formerly Hamilton and Ludington. Oliver	
		25	40	31	n½ of se¼, se¼ of se¼	Iron Mining Co......	P
I	Chatham	35	43	35	e½ of ne¼, ne¼ of se¼	Part formerly Riverton. Brule Mining Co.	
		36	43	35	w½ of nw¼ of nw¼	(Oglebay, Norton & Co.)	P
I	Chicagon	23	43	34	sw¼ of se¼	Munro Mining Co.	
		26	43	34	w½ of ne¼, se¼ of ne¼ ne¼ of se¼	(Rogers, Brown Iron Co.)	P
I	Claire	19	43	32	e½ of se¼	Now Bristol	1898
D	Clifford	20	40	30	n½ of nw¼	Antoine Ore Co. (Oglebay, Norton & Co.)..	P
I	Columbia	31	43	32	nw¼	Formerly Shafer & Sheldon, Union. Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.)	1912
F	Commonwealth (Wis.)	34	40	18E	sw¼		1892
D	Cornell	20	40	30	lots 3, 4	Antoine Ore Co. (Oglebay, Norton & Co.)..	1887
I	Corry	6	42	34	ne¼ of sw¼	Brule Mining Co. (Oglebay Norton & Co.)...	U
I	Cortland	34	43	35	e½ of se¼		1913
I	Crystal Falls	21	43	32	e½ of ne¼		1909
D	Cuff	22	40	30	sw¼		1900
D	Cundy	3	39	30	n½ of ne¼, ne¼ of nw¼		1909
D	Curry	9	39	29	w½ of ne¼	Now in Penn Group; connected with West Vulcan, 1892	
D	Cyclops	5	39	29	s½ of se¼	Now in Penn Group....	1892
F	Davidson (Wis.)	34	40	18E	nw¼ of se¼	Same as Field........	
I	Davidson No. 1....	23	43	35	ne¼ of nw¼	Davidson Ore Mining Co. (New York State Steel Co.)	P
I	Davidson No. 2.....	14	43	35	w½ of se¼	Formerly Goodman. Davidson Ore Mining Co. (New York State Steel Co.)	P
I	DeGrasse	7	42	34	ne¼	Verona Mining Co. (Pickands. Mather & Co.)	U

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
I	Delphic	24	42	33	ne¼ of sw¼		1887
I	Dober	1	42	35	nw¼	Oliver Iron Mining Co..	P
I	Dunn	1	42	33	w½ of nw¼	Dunn Iron Mining Co.	
		36	43	33	s½ of se¼	(Corrigan, McKinney & Co.)	P
D	East Vulcan	11	39	29	sw¼, s½ of se¼	Now in Penn Group....	1892
D	Emmett	22	39	28	ne¼ of ne¼		1881
I	Erickson	21	43	34	sw¼	Cleveland-Cliffs Iron Co.	U
F	Ernst (Wis.)	27	40	18E	sw¼ of sw¼	Florence Iron Co. (M. A. Hanna & Co.).....	P
I	Fairbanks	20	43	32	ne¼ of se¼	Now Paint River.......	1883
D	Federal	25	40	31	s½ of nw¼, n½ of sw¼	Oliver Iron Mining Co.	
D	Few	6	39	29	s½ of nw¼		1910
F	Field (Wis.)	34	40	18E	nw¼ of se¼	Same as Davidson (Wis.)	
F	Florence (Wis.) ..	20	40	18E	ne¼ of se¼, se¼ of ne¼	Florence Iron Co. (M. A. Hanna & Co.)....	1913
I	Fogarty	1	42	35	se¼ of se¼	Verona Mining Co. (Pickands, Mather & Co.)	P
I	Forbes	14	43	35	e½ of sw¼	Jones & Laughlin Ore Co..	P
D	Forest	25	40	30	ne¼ of sw¼		1904
I	Genesee	30	43	32	se¼	Crystal Falls Iron Mining Co. (Corrigan McKinney & Co.).......	1913
I	Gibson	15	44	33	nw¼ of nw¼		1911
I	Goodman	13	42	33	nw¼ of sw¼		
		14	42	33	e½ of se¼	Nevada Land Co.......	U
I	Goodman	14	43	35	w½ of se¼	Now Davidson No. 2...	1912
I	Great Western	21	43	32	e½ of sw½	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.).......	1908
I	Great Western Extension	21	43	32	sw¼ of se¼	Crystal Falls Iron Min-Co. (Corrigan, McKinney & Co.).......	U
D	Groveland	31	42	29	n½ of se¼	Lake Erie Ore Co......	1913
	Half and Half......					Picked from old rock piles	1891
D	Hamilton	30	40	30	n½ of sw¼	Now part of Chapin....	1892
D	Harrison	8	39	29	s½ of ne¼	Now part of Aragon...	1897
I	Hemlock	4	44	33	sw¼ of sw¼	Hemlock River Mining Co. (Pickands, Mather & Co.)	P
	Hersel						1890
D	Hewitt	31	40	30	nw¼ of ne¼, ne¼ of nw¼	Now Millie	1886
I	Hiawatha	35	43	35	sw¼ of se¼	Munro Mining Co. (Rogers, Brown Iron Co.)..	P
I	Hill Top	22	43	32	sw¼ of nw¼, lot 3	Cuyhoga Mining Co.....	P

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
I	Hollister	13	43	32	w½ of sw¼	Hollister Mining Co. (M. A. Hanna & Co.).	1911
I	Homer	23	43	35	w½ of nw¼, nw¼ of sw¼	Wickwire Mining Co. (Wickwire Steel Co.)	D
I	Hope	27	43	32	e½ of se¼	Formerly Wauneta	1893
D	Indiana	27	40	30	ne¼ of ne¼	Thomas Furnace Co....	P
I	Iron River	35 36	43 43	35 35	e½ of ne¼ w½ of nw¼	Later part of Riverton, part now in Chatham.	1899
I	Isabella	36	43	35	sw¼ of sw¼	Formerly part of Riverton. Oliver Iron Mining Co..	1900
I	James	23	43	35	n½ of ne¼	Now Osana	1910
I	Judson	13	42	33	se¼ of nw¼ except 5 acres, ne¼ of sw¼	Judson Mining Co. (Nevada Land Co.)......	P
D	Keel Ridge	32	40	30	se¼	Now part of Pewabic..	1899
I	Kimball	29	43	33	se¼ of se¼		1907
I	Konwinski	23	43	35	sw¼ of ne¼, se¼ of nw¼	Now Wauseca	1911
I	Lamont	20	43	32	lot 6	Formerly Monitor	1910
I	Lee Peck	26	43	32	sw¼ of ne¼		1889
I	Lincoln	21	43	32	w½ of sw¼	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.)	1908
D	Loretto	7	39	28	w½ of sw¼, sw¼ of nw¼	Loretto Iron Co. (M. A. Hanna & Co.)	P
I	Lot 3	20	42	32	lot 3		1882
D	Lowell	11	39	29	s½ of sw¼	Later part of East Vulcan, now in Penn Group	
D	Ludington	25	40	31	n½ of se¼, se¼ of se¼	Now part of Chapin..	1894
I	Manhattan	13	42	33	nw¼ of se¼	Same as South Mastodon	1890
I	Mansfield	17 20	43 43	31 31	lot 5 lot 8		1911
I	Mastodon	13	42	33	s½ of ne¼	Now part of Balkan....	1895
I	McDonald	23	43	32	se¼ of ne¼		1913
I	McGillis	1	42	35	ne¼ of se¼	Oliver Iron Mining Co..	U
I	McGovern	22	43	35	e½ of ne¼	Wickwire Mining Co. (Wickwire Steel Co.).	U
D	Metropolitan	32	42	28	n½ of ne¼		1888
I	Michaels	29	43	34	se¼	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.)	U
I	Michigan	9	44	33	ne¼ of nw¼	Oliver Iron Mining Co..	P
D	Millie	31	40	30	nw¼ of ne¼, ne¼ of nw¼	Formerly Hewitt. Desau Mining Co. (M. A. Hanna & Co.)	1909
I	Minckler	23	43	35	ne¼ of sw¼ w½ of nw¼ of se¼	Republic Iron & Steel Co..	U
I	Monitor	20	43	32	lot 6	Now Lamont	1894

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
I	Monongahela	36	43	33	n½ of ne¼, se¼ of ne¼ ne¼ of nw¼	Hollister Mining Co. (M. A. Hanna & Co.).....	1903
D	Munro	6	39	29	nw¼ of se¼, ne¼ of sw¼	Munro Mining Co. (Rogers, Brown Iron Co.)	1912
I	Nanaimo	26	43	35	nw¼ of sw¼	Mineral Mining Co....	1908
I	Neely	12	42	33	n½ of ne¼, ne¼ of nw¼	Cleveland-Cliffs Iron Co.	U
D	Northwestern	32	42	28	n½ of nw¼		1903
D	Norway	5	39	29	n½ of se¼	Now in Penn Group....	1892
I	Osana	23	43	35	n½ of ne¼	Formerly James. Mineral Mining Co. (Pickands, Mather & Co.)..	P
I	Paint River	20	43	32	ne¼ of sw¼, lot 5	Formerly Fairbanks ...	1892
D	Penn Group	5	39	29	s½		
		6	39	29	e½ of se¼		
		9	39	29	w½ of ne¼, sw¼ of ne¼, s½ of nw¼, nw¼ of se¼, e½ of se¼	Formerly East Vulcan, Central Vulcan, West Vulcan Curry, Brier Hill, Norway, Cyclops. Penn Iron Mining Co.	
		10	39	29	entire	(Cambria Steel Co.)..	P
		11	39	29	sw¼ s½ of se¼		
D	Perkins	4	39	29	sw¼ of sw¼	Formerly Saginaw	1891
	Perry						1883
D	Pewabic	32	40	30	entire	Pewabic Co. (Pickands, Mather & Co.).......	P
I	Purcell	14	43	35	w½ of sw¼		1913
D	Quinnesec	34	40	30	se¼		1910
I	Ravenna	19	43	32	s½ of n½, sw¼ w½ of se¼	Hollister Mining Co. (M. A. Hanna & Co.)	P
I	Riverton	35	43	35	e½ of ne¼	Part formerly Iron Riv-	
		36	43	35	w½ of w½	er, part now in Chatham, and Isabella....	1912
I	Rogers	29	43	34	ne¼	Munro Mining Co. (Rogers, Brown Iron Co.)	P
D	Saginaw	4	39	29	sw¼ of sw¼	Now Perkins	1879
I	Selden	35	43	35	ne¼ of se¼	Now part of Chatham..	1886
I	Sheldon and Shafer	31	43	32	nw¼	Formerly Union, now Columbia	1894
I	Sheriden	26	43	35	se¼ of se¼		1900
I	Sherwood	23	43	35	se¼ of ne¼, ne¼ of se¼	Republic Iron & Steel Co..	U
I	South Mastodon ...	13	42	33	nw¼ of se¼	Same as Manhattan....	1890
I	Spies	24	43	35	e½ of nw¼	Cleveland-Cliffs Iron Co.	U
D	Stephenson	4	39	29	nw¼ of sw¼		1887

	Property	Sec	T	R	Description	Operating Company (Sales Agents)	
D	Sturgeon River	7	39	28	ne¼ of sw¼	Now Appleton	1879
I	Tobin	30	43	32	sw¼	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.).......	1913
D	Traders	17	40	30	s½ of sw¼	Antoine Ore Co. (Oglebay, Norton & Co.)..	1907
I	Tully	36	43	35	s½ of se¼	Crystal Falls Iron Mining Co. (Corrigan, McKinney & Co.).......	P
I	Union	31	43	32	nw¼	Later Sheldon and Shafer, now Columbia....	1882
D	Verona	14	39	29	n½ of ne¼		1904
I	Victoria	22	43	32	nw¼ of nw¼	Cuyhoga Mining Co....	P
I	Virgil	24	43	35	sw¼ of nw¼	Wickwire Mining Co. (Wickwire Steel Co.)	1914
D	Vivian	34	40	30	s½ of sw¼		1912
D	Walpole	29	40	30	s½ of s½		
		30	40	30	e½ of se¼		
		31	40	30	e½ of ne¼		1891
I	Warner	9	44	33	e½ of se¼	Hemlock River Mining Co. (Pickands, Mather & Co.)	D
I	Wauneta	27	43	32	e½ of se¼	Now Hope	1887
I	Wauseca	23	43	35	sw¼ of ne¼, se¼ of nw¼	Formerly Konwinski. Mineral Mining Co. (Pickands, Mather & Co.)	P
D	West Vulcan	9	39	29	se¼ of ne¼, nw¼ of se¼ e½ of se¼	Now in Penn Group....	1892
I	White	29	43	34	e½ of nw¼	Swallow and Hopkins..	U
I	Wickwire	35	43	35	nw¼ of ne¼, ne¼ of nw¼	Wickwire Mining Co. (Wickwire Steel Co.).	P
I	Young	6	42	34	s½ of sw¼	Verona Mining Co. (Pickands, Mather & Co.)	U
I	Youngs	12	42	35	e½ of e½		1913
I	Youngstown	20	43	32	w½ of sw¼		1887
I	Zimmerman	7	42	34	e½ of nw¼	Spring Valley Mining Co..	P

Gogebic Range.

Properties in Michigan are in Gogebic county, in Wisconsin in Iron county.

Property	Sec	T	R	Description	Operating Company (Sales Agents)	
Ada	17	47	46	s½	Formerly Ruby, Ironton, and Federal, now Puritan, Ironton, and Winona	1903
Alpha	9	47	45	e½ of nw¼	Part now in Pike.......	1895

Property	Sec	T	R	Description	Operating Company (Sales Agents)	
Anvil	14	47	46	ne¼	Newport Mining Co. (M. A. Hanna & Co.).....	P
Ashland	22	47	47	s½ of sw¼		
	27	47	47	part of n½ of nw¼	Hayes Mining Co.......	P
Asteroid	13	47	46	ne¼	Castile Mining Co. (Oglebay, Norton & Co.)	P
Atlantic (Wis.)	1	45	1E	s½ of ne¼, n½ of se¼, sw¼ of se¼, e½ of sw¼, sw¼ of sw¼		
	12	45	1E	nw¼ of nw¼	Oliver Iron Mining Co..	P
Aurora	23	47	47	e½ of sw¼	Oliver Iron Mining Co..	P
Bessemer (Wis.) ..						
Blue Jacket	8	47	46	se¼	Now Royal	1887
Bonnie	13	47	47	se¼ of se¼	Newport Mining Co. (M.	
	24	47	47	ne¼	A. Hanna & Co.).....	P
Brotherton	9	47	45	n½ of se¼, se¼ of ne¼	Part formerly Crown Point. Brotherton Iron Mining Co. (Pickands, Mather & Co.).......	P
Cary (Wis.)	26	46	2E	nw¼		
	26	46	2E	n½ of ne¼	Parts formerly Kakagon, Nimikon, Superior, West Cary and Windsor. Odanah Iron Co. (Pickands, Mather Co.)	P
	27	46	2E	se¼ of ne¼, ne¼ of se¼		
Castile	10	47	45	e½	Castile Mining Co. (Oglebay, Norton & Co.)	P
Chicago	8	47	45	e½ of ne¼		
	9	47	45	w½ of nw¼	Part formerly Sparta..	1903
Colby	16	47	46	ne¼	Corrigan, McKinney & Co..	P
Comet	11	47	45	s½ of sw¼	Now part of Meteor....	1894
Crown Point	9	47	45	n½ of se¼	Now part of Brotherton	1890
Dangler	13	47	46	w½ of nw¼	Part now in Eureka...	1892
Davis	19	47	46	n½ of nw¼	Formerly part of First National. Oliver Iron Mining Co..	P
East Norrie	23	47	47	w½ of sw¼	Oliver Iron Mining Co..	P
Eureka	13	47	46	n½ of nw¼	Part formerly of Dangler. Castile Mining Co. (Oglebay, Norton & Co.)	P
Federal	17	47	46	e½ of se¼	Later part of Ada, now Winona	1892
First National	19	47	46	nw¼	Part now in Davis....	1887
Geneva	18	47	46	sw¼	Oliver Iron Mining Co..	P
Germania (Wis.) ..	24	46	2E	s½ of sw¼	Harmony Iron Co.	
	25	46	2E	n½ of nw¼	(Hayes Mining Co.)..	1911

Property	Sec	T	R	Description	Operating Company (Sales Agents)	
Hennipin (Wis.)	34	46	2E	ne¼		1912
Houghton County	11	47	46	s½ of sw¼	Newport Mining Co.	U
Iron Belt (Wis.)	11	45	1E	ne¼, se¼ of nw¼ ne¼ of sw¼, w½ of sw¼		1909
Iron Chief	10	47	45	e½ of sw¼	Now part of Sunday Lake	1887
Iron King	24	47	47	nw¼	Later Mount Hope, now Newport	1889
Ironton	17	47	46	w½ of se¼	Once part of Ada. Corrigan, McKinney & Co.	1914
Jack Pot	16	47	46	n½ of sw¼	Formerly part of Valley	1904
Kakagon (Wis.)	26	46	2E	e½ of nw¼	Now part of Cary	
Keweenaw	11	47	46	s½ of se¼	Newport Mining Co.	U
Meteor	11	47	45	sw¼, s½ of nw¼	Part formerly Comet. Castile Mining Co., (Oglebay, Norton & Co.)	D
Mikado	18	47	45	nw¼, nw¼ of ne¼	Verona Mining Co., (Pickands, Mather & Co.)	P
Minnewawa (Wis.)	24	46	2E	lots 4, 5	Hayes Mining Co.	P
Montreal (Wis.)	33	47	2E	w½ of ne¼, nw¼	Part formerly Section 33, Trimble. Montreal Mining Co. (Oglebay, Norton & Co.)	P
Mount Hope	24	47	47	nw¼	Formerly Iron King, now Newport	1891
Newport	24	47	47	nw¼	Formerly Iron King, Mount Hope. Newport Mining Co. (M. A. Hanna & Co.)	P
Nimikon	26	47	2E	n½ of ne¼	Later Windsor, now part of Cary	1886
Norrie	22	47	47	s½ of se¼	Oliver Iron Mining Co.	P
North Aurora	23	47	47	s½ of nw¼	Oliver Iron Mining Co.	P
North Norrie	22	47	47	n½ of se¼	Oliver Iron Mining Co.	P
North Pabst	23	47	47	n½ of ne¼	Oliver Iron Mining Co.	P
Odanah (Wis.)	27	46	2E	e½ of sw¼, w½ of se¼	Now Ottawa	
Ottawa (Wis.)	27	46	2E	e½ of sw¼, w½ of se¼	Formerly Odanah. Montreal Mining Co. (Oglebay, Norton & Co.)	P
Pabst	23	47	47	s½ of ne¼	Oliver Iron Mining Co.	P
Palms	14	47	46	nw¼	Newport Mining Co. (M. A. Hanna & Co.)	P
Pence (Wis.)	32	46	2E	se¼		1912
Pike	9	47	45	sw¼ of ne¼, se¼ of nw¼	Part formerly in Alpha.	1910

Property	Sec	T	R	Description	Operating Company (Sales Agents)	
Pilgrim	18	47	45	ne¼ of ne¼, s½ of ne¼	Pickands, Mather & Co.	U
Plumer (Wis.)	6	45	2E	n½	Oliver Iron Mining Co..	P
Presque Isle	21	47	43	w½ of w½, ne¼ of nw¼	Presque Isle Mining Co.	D
Puritan	17	47	46	sw¼	Formerly Ruby and part of Ada. Oliver Iron Mining Co..	P
Royal	18	47	46	se¼	Formerly Blue Jacket. Oliver Iron Mining Co.	U
Ruby	17	47	46	sw¼	Later part of Ada, now Puritan	
Section No. 3 (Wis.)	33	46	2E	e½ of nw¼	Now part of Montreal..	
Shores (Wis.)	10	45	1E	se¼ of sw¼, se¼		1899
Sparta	9	47	45	w½ of nw¼	Now part of Chicago...	1895
Sunday Lake	10	47	45	w½	Part formerly Iron Chief. Sunday Lake Iron Co. (Pickands, Mather & Co.).......	P
Superior (Wis.) ...	27	46	2E	se¼ of ne¼, ne¼ of se¼	Now part of Cary......	P
Tilden	15	47	46	n½	Oliver Iron Mining Co..	P
Trimble (Wis.)	33	46	2E	nw¼ of ne¼	Now part of Montreal..	
Tylers Forks (Wis.)	33	45	1W	nw¼ of se¼		
Valley	16	47	46	s½ of nw¼, n½ of sw¼	Part later West Colby, now Yale, part now Jackpot	1896
Vaughn	23	47	47	n½ of se¼	Oliver Iron Mining Co..	P
Wakefield	16	47	45	w½ of nw¼, nw¼ of sw¼		
	17	47	45	s½ of n½, n½ of s½	Wakefield Mining Co. (M. A. Hanna & Co.).	P
West Colby	16	47	46	s½ of nw¼	Formerly part of Valley, now Yale	1903
West Cary (Wis.)..	26	46	2E	w½ of nw¼	Now part of Cary......	
Windsor (Wis.) ...	26	46	2E	n½ of ne¼	Formerly Nimikon, now part of Cary.........	P
Winona	17	47	46	e½ of se¼	Formerly Federal, part of Ada. Corrigan, McKinney & Co.........	1914
Yale	16	47	46	s½ of nw¼	Formerly part of Valley, later West Colby Lake Superior Iron & Chemical Co. (Oglebay, Norton & Co.)..	P

REPORT OF THE FIRST ANNUAL FIRST-AID CONTEST.

BY C. S. STEVENSON, ANNOUNCER.

Historical—Although the inception of the work of first-aid to the injured and the use of mine rescue breathing apparatus, in the Lake Superior district, followed the development of this work in other districts, yet since the inauguration of this work four or five years ago, its development has been rapid throughout the entire district, and at the present time scarcely a company remains which has not given serious attention to the instruction of miners in work of this character.

The development of the idea of safety in mining has perhaps resulted largely from the tremendous "Safety First" movement which has invaded all industries throughout America within the past 10 years. In the year 1911 and 1912 several safety inspectors of mining companies and county mine inspectors from Michigan and Minnesota attended the National Mine Safety Demonstrations at Pittsburgh, Pa. These men returned with a greater appreciation of the development of safety work in other districts and with a renewed determination for the fullest development of safety in mining throughout the Lake Superior mining district. In the year 1912 this interest resulted in a request from the Lake Superior district, which was presented to the Federal Bureau of Mines, asking for the permanent establishment of a mine rescue car in the district. The Bureau of Mines acted favorably on this request and in November, 1912, the government instructors arrived, followed shortly thereafter by the rescue car, which was in course of construction. This car has up to the present time given training throughout the entire district and the present development of the work of first-aid to the injured and in the use of mine rescue breathing apparatus is largely a compliment to this governmental assistance.

In the year 1912 the Institute appointed a Committee on the Practice for the Prevention of Accidents and this committee represented the first active interest by the Institute in safety work. This committee in session with the President and Secretary of the Institute in a meeting held at Ishpeming, on April 10th, 1914, considered the possibility of holding a joint program in first-aid and mine rescue work in conjunction with the American Mine Safety Association. The possibility of having such a joint program in connection with the annual meeting of the Institute was fully discussed. However, the plans of the Institute were such that only one day could be devoted to this feature and as a consequence the committee recommended holding the first-aid contest under the auspices

TREATMENT FOR BURNS BY THE LAKE MINE TEAM OF THE CLEVELAND-CLIFFS IRON CO.

of the Institute. The report also suggested that later cooperation with the American Mine Safety Association in such a program might be given. It was further recommended that the Institute hold a first-aid contest each year as a feature of its annual program.

Preliminary Announcement—On June 18, 1914, the Committee of the Institute on the Practice for the Prevention of Accidents addressed a preliminary announcement to the mining companies of the Lake Superior district to the effect that a first-aid contest would be held at Ishpeming, Michigan, in connection with the annual meeting of the Institute and outlining the rules to be followed in the contest and the discounts for judging. These rules and discounts are given below.

ENTRANCE RULES.

1. All entries shall close July 20th, and must be filed with William Conibear, Ishpeming, Michigan.
2. A team is composed of five men, including a captain.
3. Each team will select its own patient in addition to the five operating members thereof, or will have a miner present, selected for them.
4. All members of a team shall be bona fide mine workers.
5. The teams will bring their own first-aid material including bandages, splints, blankets, stretchers, etc., and will not be allowed to leave the patient to secure material.

CONTEST RULES.

1. The captain will select the patient and designate the member or members of the team to perform the event.
2. The captain will control his team in their field of work by giving audible commands.
3. The captain may select himself as one of the members who will perform the event.
4. The captain or other members will not prompt the person performing the event unless he is one of the performers. This will not apply to full team events.
5. At the conclusion of any event the captain will raise his right hand and announce his team number. The team will remain at post until relieved by the judges.
6. The triangular bandage will be the standard used in the contest, but roller bandages may be used and equal credit will be given for their proper use as with the triangular bandages.
7. All splints must be prepared on the field for each event requiring their use. Specially designed splints may be used, but they must be assembled during the time of each event requiring their use.
8. No practicing will be allowed on the field before the beginning of the contest.
9. The teams will be numbered consecutively, beginning at No. 1, and they will occupy their consecutive positions on the field.
10. Each judge will mark the team number, event, and discounts for each team judged, sign his name and deliver, to the recorder, his record.
11. The recorder will foot up the discounts and mark points made by each team in each event. The total points will be divided by the number of events and the quotient will be the average for each team for the whole contest.
12. Time will not be an element unless the team or men performing run over the alloted time or fail to give treatment properly. All events shall commence and be finished at the sounding of a gong.
13. All exception to these rules must be made to the Committee on the Practice for the Prevention of Accidents, Mr. Charles E. Lawrence, Chairman, Palatka, Michigan, not later than 30 days prior

to the day of the contest. The decision of the Committee will be final.

DISCOUNTS FOR JUDGING FIRST-AID CONTEST.

		Discounts (Points)
1.	Not doing the most important thing first	5
2.	Failure of captain to command properly	2
3.	Slowness in work and lack of attention	4
4.	Failure to entirely cover the wound or being unable to give location of injury	4
5.	Ineffective artificial respiration	10
6.	Splint improperly padded or applied	2
7.	Tight, loose, or improperly applied bandage	6
8.	Insecure or granny knot	5
9.	Unclean first-aid material	5
10.	Failure to have on hand sufficient and proper material to complete a dressing	5
11.	Lack of neatness	2
12.	Awkward handling of patient	5
13.	Assistance lent by patient	5
14.	Tourniquet improperly applied	5
15.	Failure to stop bleeding	5
16.	Not treating shock	5
17.	Failure to be aseptic	10
18.	Improper treatment	10
19.	Failure to finish in the allotted time should be discounted 1 point for each minute over time.	

A second announcement was distributed on July 10th to those companies who had signified their intention of entering teams in the contest. In this announcement the date and place of holding the contest was given and twenty first-aid problems were submitted from which ten were to be selected for the contest. These problems and additional rules which were included in this announcement are given below.

EVENTS.

No. 1. **One-Man Event**—Treat a lacerated wound of the forehead and a lacerated wound in the palm of the right hand.

No. 2. **One-Man Event**—Treat a lacerated wound on the point of the left shoulder and a scald of the right hand and right fore-arm.

No. 3. **One-Man Event**—Right cheek cut and bleeding; right fore-arm cut and bleeding.

No. 4. **One-Man Event**—Treat a simple fracture of the right collar-bone and simple fracture of the lower jaw.

No. 5. **Two-Men Event**—Treat a dislocated shoulder and simple fracture of right leg.

No. 6. **Two-Men Event**—Flesh torn off back of left hand; compound fracture of the right arm.

No. 7. **Three-Men Event**—Left ear torn off; left shoulder dislocated; compound fracture of left leg.

No. 8. **Three-Men Event**—Head, face, neck, arms and hands burned with ignition of acetylene gas.

No. 9. **Four-Men Event**—Patient unconscious from gas inhalation; right fore-arm broken; improvise stretcher and carry 50 feet.

No. 10. **Four-Men Event**—Man is found lying on his back on live electric wire, unconscious; back burned at waist line; demonstrate three methods of his removal, treat and carry on stretcher 50 feet.

No. 11. **Team Event**—Treat a broken knee-cap and a fracture of the ribs.

No. 12. **Team Event**—Treat a fractured right ankle and a fracture of the left upper arm.

No. 13. **Team Event**—Treat a man insensible from drowning. (Any method of artificial respiration may be used.)

THE WINNING TEAM OF THE HARTFORD MINE APPLYING SPLINTS FOR A FRACTURED THIGH.

No. 14. **Team Event**—Treat a man insensible from gas or smoke. (Any method of artificial respiration may be used.)

No. 15. **Team Event**—Treat a broken back.

No. 16. **Team Event**—Treat a compound fracture of the middle third of the right thigh accompanied by violent bleeding.

No. 17. **Team Event**—Left leg cut off six inches below knee; simple fracture of right leg.

No. 18. **Team Event**—Right hand cut off by motor wheels; dislocated left hip.

No. 19. **Team Event**—Simple fracture of right thigh; fifth and sixth ribs on left side broken; compound fracture of right wrist, with bright red blood bleeding.

No. 20. **Team Event**—Simple fracture of both fore-arms; great toe on right foot cut off; treat and two men carry 50 feet without stretcher.

The teams entered will be numbered consecutively. Those having even numbers will perform even numbered events and those having odd numbers will perform odd numbered events. Each team will be identified on the field by a number worn by the Captain, the same corresponding to the number on the printed list of teams on the final program.

The beginning and closing of each event will be designated by the sounding of a gong.

Judging—It was decided by the Committee to procure three men for judges of the contest who were in no way identified with the mining industry of the district and who as well were thoroughly informed in first-aid methods and contests. The three men finally selected were as follows:

Dr. A. F. Knoefel, Vice President and Chief Surgeon of the Vandalia Coal Company, Linton, Ind.

Mr. R. Y. Williams, Director, Illinois Miners' and Mechanics' Institute, Urbana, Ills.

Mr. G. H. Hawes, Rescue Engineer, Pittsburgh, Pa.

These men performed their duties in an admirable manner and expressed themselves after the contest as being most favorably impressed with the standard of first-aid work in this district. The Institute is highly appreciative of the very valuable services of these three men. A score card was prepared for the use of the judges which simplified their duties very greatly. A copy of this score card is given below.

First Annual First Aid Contest
LAKE SUPERIOR MINING INSTITUTE.
Score Card

(Reduced) **Team No...........**

Discounts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Grade for Ev'nt
Event No.																				
" "																				
" "																				
" "																				
" "																				

Final Grade..........

Program—The ten problems selected for the contest and the mining companies represented together with the personnel of the teams were given in a special program which was distributed on the morning of the day of the contest. This program is given below.

ORDER OF EVENTS.

No. 1. **One-Man Event**—Treat a lacerated wound of the forehead and a lacerated wound in the palm of the right hand. (6 minutes.)

No. 2. **One-Man Event**—Treat a simple fracture of the right collar-bone and simple fracture of the lower jaw. (6 minutes.)

No. 3. **Three-Men Event**—Left ear torn off; left shoulder dislocated; compound fracture of left leg. (12 minutes.)

No. 4. **Three-Men Event**—Head, face, neck, arms and hands burned with ignition of acetylene gas. (10 minutes.)

No. 5. **Team Event**—Treat a man insensible from drowning. (Any method of artificial respiration may be used.) (5 minutes.)

No. 6. **Team Event**—Treat a man insensible from gas or smoke. (Any method of artificial respiration may be used.) (5 minutes.)

No. 7. **Team Event**—Treat a broken back. (12 minutes.)

A GENERAL VIEW SHOWING THE TEAMS IN LINE AT THE BEGINNING OF THE CONTEST.

No. 8. **Team Event**—Treat a compound fracture of the middle third of the right thigh accompanied by violent bleeding. (10 minutes.)

No. 9. **Team Event**—Right hand cut off by motor wheels; dislocated left hip. (12 minutes.)

No. 10. **Team Event**—Simple fracture of right thigh; fifth and sixth ribs on left side broken; compound fracture of right wrist, with bright red blood bleeding. (12 minutes.)

Each team will be identified on the field by a number worn by the Captain; the same corresponding to the number on the printed list of teams on this program. Teams having even numbers will perform even numbered events and those having odd numbers will perform odd numbered events.

The beginning and closing of each event will be designated by sounding of a gong.

Announcer.

C. S. Stevenson, Educational Director, The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Time-Keeper.

W. M. Webb, Safety Inspector, Republic Iron & Steel Co., Gilbert, Minnesota.

COMPANIES REPRESENTED AND PERSONNEL OF TEAMS.

No. 1 Team—Oliver Iron Mining Co., Gogebic Range. Captain, Edward Hancock, Thomas Sampson, William J. Sampson, Herman Kekoletic, George Bowater and Thomas Mills, (subject.)

No. 2 Team—Cleveland-Cliffs Iron Co., Lake Mine, Ishpeming. Captain, Xavier Pepin, Wm. Wilcox, Thomas Home, Richard Lemin, Wm. Bennett and Edward Mandley, (subject.)

No. 3 Team—Pickands, Mather & Co., Mesabi Range. Captain, James R. Fayle, George Crago, Reginald Coombs, Wm. Glanville, Maurice Westerlund and Oscar Creer, (subject.)

No. 4 Team—Republic Iron & Steel Co., Mesabi Range. Captain, H. S. Hammond, P. Donahue, James Bresnahan, B. C. Hanson, Thos. Sheardy and F. R. Kane, (subject.)

No. 5 Team—Oliver Iron Mining Co., Marquette Range. Captain, Harry T. Hulst, William Hatch, Chas. K. Doney, William Mitchell, William Richards and Horace Jewell, (subject.)

No. 6 Team—Cleveland-Cliffs Iron Co., Gwinn District, Captain, Sidney Harvey, William Johns, W. H. Matthews, Joseph Andrews, Agner Blomquist and William Goyen, (subject.)

No. 7 Team—Republic Iron & Steel Co., Marquette Range. Captain, Paul Mitchell, James Davey, Antoine Cesare, George Curnow and John Gaviglio.

No. 8 Team—Newport Mining Co., Gogebic Range. Captain, Axel Holmgren, Joe Winn, Ernest Russ, Arthur Westergren, Tony Petruscak and Otto Peterson, (subject.)

No. 9 Team—Cleveland-Cliffs Iron Co., Maas Mine, Negaunee. Captain, Thomas Easterbrook, Ben

Remaly, James Hawke, Joseph Gambetti, and Wm. Waters, (subject.)

No. 10 Team—Pickands, Mather & Co., Iron River District. Captain, James Johns, Kyme Scuffham, John G. Williams, John Manning, Dan Cummings and William Bengry, Jr., (subject.)

No. 11 Team—Cleveland-Cliffs Iron Co., Negaunee Mine, Negaunee. Captain, J. S. McNabb, Samuel Stephens, Enock Vincent, George Whittington, Arthur Olson and Fred Staples, (subject.)

No. 12 Team—The Breitung Iron Co., Marquette Range. Captain, Fred Royce, Will Thomas, Herman Burgeson, Albert Larson and John Donnithorne.

Prizes—The Institute is greatly indebted to several firms and societies who presented valuable prizes to winning teams, in addition to the fifty dollars in gold which the Institute has decided to offer annually. These prizes were as follows:

E. I. DuPont DeNemours Powder Co.,—Fifty Dollars in Gold.

The Pluto Powder Co., Ishpeming, Michigan—Six Silk Umbrellas, with appropriately engraved silver mounted handles.

The American Mine Safety Association—Bronze Medals.

The Draeger Oxygen Apparatus Co., Pittsburgh, Pa.—A Self Rescue Apparatus, valued at $50.00.

The cash prizes offered were combined and distributed as is shown below:

First Prize—Five Bronze Medals and $50.00 Cash.

Second Prize—Six Silk Umbrellas and $30.00 Cash.

Third Prize—One Self-Rescue Apparatus and $20.00 Cash.

Decision of the Judges—The decision of the judges was not made known at the immediate close of the contest but some two hours afterward at a baseball game, which was given for the entertainment of the members of the Institute, the members of the first-aid teams and their friends. Previous to the announcment of the judges it was necessary to work off a tie existing for third place. Three teams, as follows, were tied for this position:

The Oliver Iron Mining Company, Ishpeming, Michigan.

The Newport Iron Company, Ironwood, Michigan.

The Cleveland-Cliffs Iron Company, Maas Mine, Negaunee, Michigan.

The judges selected the following problem to decide the winner of third place:

Treat a fractured knee-cap of the right leg and a right heel cut off.

As a result of this second contest, the team of the Oliver Iron Mining Company, Ishpeming district, was declared the winner of third place. Between innings of the baseball game Dr. A. F. Knoefel, first vice president of the Vandalia Coal Company, and chief surgeon of that organization, in a well chosen speech, delivered in front of the grandstand, announced the names of the winning teams and presented the prizes to the captains. The decision of the judges gave first prize to the Republic Iron & Steel Co.-Hartford Mine team, Negaunee, Mich.; second prize to The Cleveland-Cliffs Iron Co.-Negaunee Mine team, Negaunee, Mich.; and third prize to the Oliver Iron Mining Co. Ishpeming team, Ishpeming, Mich.

PAST OFFICERS.

PRESIDENTS.

Nelson P. Hulst	1893	O. C. Davidson	1904
J. Parke Channing	1894	James MacNaughton	1905
John Duncan	1895	Thomas F. Cole	1906
William G. Mather	1896	Murray M. Duncan	1908
William Kelly	1898	D. E. Sutherland	1909
Graham Pope	1900	William J. Richards	1910
W. J. Olcott	1901	F. W. Denton	1911
Walter Fitch	1902	Pentecost Mitchell	1912
George H. Abeel	1903	W. H. Johnston	1913

(No meetings were held in 1897, 1899 and 1907.)

VICE PRESIDENTS.

1893.

John T. Jones		Graham Pope
F. P. Mills	J. Parke Channing	M. W. Burt

1894.

John T. Jones		Graham Pope
F. P. Mills	R. A. Parker	W. J. Olcott

1895.

F. McM. Stanton		Per Larsson
Geo. A. Newett	R. A. Parker	W. J. Olcott

1896.

F. McM. Stanton		Per Larsson
Geo. A. Newett	J. F. Armstrong	Geo. H. Abeel

1898.

E. F. Brown		Walter Fitch
James B. Cooper	Ed. Ball	Geo. H. Abeel

1900.

O. C. Davidson		J. H. McLean
T. F. Cole	M. M. Duncan	F. W. Denton

1901.

J. H. McLean		F. W. Denton
M. M. Duncan	Nelson P. Hulst	William Kelly

1902.

William Kelly		H. F. Ellard
Nelson P. Hulst	Fred Smith	Wm. H. Johnston

1903.

H. F. Ellard		Wm. H. Johnston
Fred Smith	James B. Cooper	John H. McLean

1904.

H. F. Ellard		John H. McLean
Wm. H. Johnston	Fred Smith	James B. Cooper

1905.

M. M. Duncan		John H. McLean
Fred M. Prescott	F. W. McNair	J. B. Cooper

1906.

M. M. Duncan		F. W. McNair
J. M. Longyear	Fred M. Prescott	F. W. Denton

1908.

J. M. Longyear		D. E. Sutherland
F. W. Denton	David T. Morgan	Norman W. Haire

1909.

W. J. Richards		D. E. Sutherland
Charles Trezona	D. T. Morgan	Norman W. Haire

1910.

W. J. Richards		Charles Trezona
John M. Bush	Frederick W. Sperr	James H. Rough

1911.

E. D. Brigham		C. H. Munger
John M. Bush	Frederick W. Sperr	James H. Rough

1912.

E. D. Brigham		C. H. Munger
Geo. H. Abeel	W. P. Chinn	W. H. Jobe

1913.

Geo. H. Abeel		A. D. Edwards
Francis J. Webb	W. P. Chinn	W. H. Jobe

MANAGERS.

1893.

John Duncan		James MacNaughton
Walter Fitch	William Kelly	Charles Munger

1894.

Walter Fitch		C. M. Boss
John Duncan	M. E. Wadsworth	O. C. Davidson

1895.

F. P. Mills		C. M. Boss
Ed. Ball	M. E. Wadsworth	O. C. Davidson

1896.

F. P. Mills		Graham Pope
Ed. Ball	C. H. Munger	William Kelly

	1898.	
M. M. Duncan		Graham Pope
J. D. Gilchrist	T. F. Cole	O. C. Davidson
	1900.	
E. F. Brown		Walter Fitch
Ed. Ball	James B. Cooper	George H. Abeel
	1901.	
James B. Cooper		James Clancey
James MacNaughton	(One Vacancy)	J. L. Greatsinger
	1902.	
James Clancey		Graham Pope
J. L. Greatsinger	Amos Shephard	T. F. Cole
	1903.	
Graham Pope		T. F. Cole
Amos Shephard	W. J. Richards	John McDowell
	1904.	
John McDowell		Thomas F. Cole
Wm. J. Richards	Graham Pope	Amos Shephard
	1905.	
John C. Greenway		H. B. Sturtevant
John McDowell	William Kelly	Wm. J. Richards
	1906.	
John C. Greenway		H. B. Sturtevant
Jas. R. Thompson	William Kelly	Felix A. Vogel
	1908.	
James R. Thompson		J. Ward Amberg
Felix A. Vogel	John C. Greenway	Pentecost Mitchell
	1909.	
F. E. Keese		J. Ward Amberg
W. J. Uren	L. M. Hardenburg	Pentecost Mitchell
	1910.	
Frank E. Keese		L. M. Hardenburg
Charles E. Lawrence	William J. Uren	William J. West
	1911.	
Charles E. Lawrence		William J. West
Peter W. Pascoe	J. B. Cooper	L. C. Brewer
	1912.	
M. H. Godfrey		J. E. Jopling
Peter Pascoe	J. B. Cooper	L. C. Brewer
	1913.	
M. H. Godfrey		J. E. Jopling
G. S. Barber	Wm. H. Johnston	C. H. Baxter

TREASURERS.

C. M. Boss 1893
A. C. Lane 1894

Geo. D. Swift 1895-1896
A. J. Yungbluth 1898-1900
Geo. H. Abeel 1901-1902
E. W. Hopkins ....1903-....

SECRETARIES.

F. W. Denton 1893-1896
F. W. Denton and F. W. Sperr....................................1898
F. W. Sperr 1900
A. J. Yungbluth ....1901-....

LIST OF PUBLICATIONS RECEIVED BY THE INSTITUTE.

American Institute of Mining Engineers, 99 John Street, New York City.
Mining and Metallurgical Society of America, 505 Pearl Street, New York City.
American Society of Civil Engineers, 220 West 57th Street, New York City.
Massachusetts Institute of Technology, Boston, Mass.
Western Society of Engineers, 1734-41 Monadnock Block, Chicago.
The Mining Society of Nova Scotia, Halifax, N. S.
Canadian Mining Institute, Ottawa.
Canadian Society of Civil Engineers, Montreal.
Institute of Mining Engineers, Neville Hall, Newcastle-Upon-Tyne, England.
North of England Institute of Mining and Mechanical Engineers, Newcastle-Upon-Tyne, England.
Chemical, Metallurgical and Mining Society of South Africa, Johannesburg, S. A.
American Mining Congress, 1510 Court Place, Denver, Colo.
State Bureau of Mines, Colorado, Denver, Colo.
Reports of the United States Geological Survey, Washington, D. C.
Geological Survey of Ohio State University, Columbus, O.
Geological Survey of New South Wales, Sydney, N. S. W.
Oklahoma Geological Survey, Norman, Okla.
University of Oregon, Library, Eugene, Oregon.
Case School of Applied Science, Department of Mining & Metallurgy, Cleveland, Ohio.
University of Illinois, Exchange Department, Urbana, Ills.
University of Missouri, Columbia, Mo.
University of Michigan, Ann Arbor, Mich.
University of Colorado, Boulder. Colo.
Columbia University, New York City, N. Y.
University of Pittsburg, State Hall, Pittsburg, Pa.
Iowa State College, Ames, Iowa.
The Mining Magazine, 178 Salisbury House, London, E. C.
Mines and Mining, 1824 Curtis Street, Denver, Colo.
Engineering-Contracting, 355 Dearborn Street, Chicago, Ills.
Mining & Engineering World, Monadnock Block, Chicago, Ills.
Mining Science, Denver Colo.
Mining & Scientific Press, 667 Howard Street, San Francisco, Cal.
The Mexican Mining Journal, Mexico City, Mexico.
Stahl und Eisen, Dusseldorf, Germany, Jacobistrasse 5.
The Excavating Engineer, 267 National Avenue, Milwaukee, Wis.

PRODUCING MINES OF MARQUETTE RANGE.

Name.	Operator.	Location.	Manager.	Address.
Lake	Cleveland-Cliffs I. Co	Ishpeming	M. M. Duncan	Ishpeming
Cliffs Shaft	Cleveland-Cliffs I. Co	Ishpeming	M. M. Duncan	Ishpeming
Salisbury	Cleveland-Cliffs I. Co	Ishpeming	M. M. Duncan	Ishpeming
Maas	Cleveland-Cliffs I. Co	Negaunee	M. M. Duncan	Ishpeming
Negaunee	Cleveland-Cliffs I. Co	Negaunee	M. M. Duncan	Ishpeming
Morris-Lloyd	Cleveland-Cliffs I. Co	North Lake	M. M. Duncan	Ishpeming
Chase	Cleveland-Cliffs I. Co	Dexter	M. M. Duncan	Ishpeming
Republic	Cleveland-Cliffs I. Co	Republic	M. M. Duncan	Ishpeming
Stephenson	Cleveland-Cliffs I. Co	Princeton	M. M. Duncan	Ishpeming
Gwinn	Cleveland-Cliffs I. Co	Gwinn	M. M. Duncan	Ishpeming
Lake Superior Hematite	Oliver I. Mining Co	Ishpeming	W. H. Johnston	Ishpeming
Section 16	Oliver I. Mining Co	Ishpeming	W. H. Johnston	Ishpeming
Prince of Wales	Oliver I. Mining Co	Negaunee	W. H. Johnston	Ishpeming
Blue	Oliver I. Mining Co	Negaunee	W. H. Johnston	Ishpeming
Stegmiller	Oliver I. Mining Co	Princeton	W. H. Johnston	Ishpeming
Cambria	Republic I. & S. Co	Negaunee	F. J. Webb	Duluth
American	American-Boston Mg. Co	Diorite	J. R. Thompson	Ishpeming
Lake Angeline	Pittsburg & L. A. I. Co	Ishpeming	Thos. Walters	Ishpeming
Rolling Mill	Pittsburg & L. A. I. Co	Negaunee	Thos. Walters	Ishpeming
Mary Charlotte	Marie Charlotte Mg. Co	Negaunee	E. N. Breitung	Marquette
Breitung Hematite	Marie Charlotte Mg. Co	Negaunee	E. N. Breitung	Marquette
Portland	Munroe Mining Co	Michigamme	G. L. Woodworth	Iron River

IDLE MINES OF MARQUETTE COUNTY.

Name.	Operator.	Location.	Manager.	Address.
Princeton	Cleveland-Cliffs I. Co	Princeton	M. M. Duncan	Ishpeming
Austin	Cleveland-Cliffs I. Co	Princeton	M. M. Duncan	Ishpeming
South Jackson	Cleveland-Cliffs I. Co	Negaunee	M. M. Duncan	Ishpeming
Imperial	Cleveland-Cliffs I. Co	Michigamme	M. M. Duncan	Ishpeming
Champion	Oliver I. Mining Co	Beacon	W. H. Johnston	Ishpeming
Section 21	Oliver I. Mining Co	Winthrop	W. H. Johnston	Ishpeming
L. S. Hard Ore	Oliver I. Mining Co	Ishpeming	W. H. Johnston	Ishpeming
Mitchell	Pittsburg & L. A. I. Co	Winthrop	Thos. Walters	Ishpeming
Barron	Washington Iron Co	Humboldt	E. N. Breitung	Marquette
Richmond	Richmond Iron Co	Palmer	J. D. Ireland	Duluth
Empire	Empire Iron Co	Palmer	E. W. Hopkins	Commonwealth
Volunteer	Volunteer Ore Co	Palmer	Thos. Pellow	Negaunee

MINES BEING DEVELOPED.

Name.	Operator.	Location.	Manager.	Address.
Athens	Cleveland-Cliffs I. Co	Negaunee	M. M. Duncan	Ishpeming
Iron Mountain Lake	Pittsburg & L. A. I. Co	Ishpeming	Thos. Walters	Ishpeming
Lucky Star	Breitung Hematite Mg. Co	Negaunee	E. N. Breitung	Marquette
Isabella	Cascade Mg. Co	Palmer	O. B. Warren	Hibbing

ABANDONED MINES ON MARQUETTE RANGE.

(Partially Complete.)

Albion	Etna	Manganese	Platt
Ames	Fitch	Marine	Primrose
Argyle	Foster	Metropolitan	Richards
Asteroid	Foxdale	Michigamme	Riverside
Barassa	Franklin	Michigan	Ropes
Bay State	Gibson	Milwaukee-Davis	Saginaw
Beaufort	Goodrich	Mitchell	Schouldice
Bessie	Grand Rapids	Moore	Spurr
Brotherton	Grant	Nelson	Star West
Bunker Hill	Himrod	New York	Standard
Catherine	Holyoke	Northampton	St. Lawrence
Cheshire	Hortense	Norwood	Tilden
Dalliba	Humboldt	Ogden	Titan
Detroit	Jim Pascoe	Old Champion	Webster
Dey	Keystone	Palmer	Wheeling
East New York	Kloman	Pendill	Whetmore
Edison	Lincoln	Phoenix	
Erie	Magnetic	Pioneer	

IRON ORE SHIPMENTS FROM MARQUETTE RANGE.

FROM IRON TRADE REVIEW

Mine—	1913.	All Years.
American	162,253	894,167
Austin	107,366	936,599
Breitung Hematite	104,757	782,444
Cambria	169,473	2,817,842
Chase	52,930	52,930
Cleveland-Cliffs Group (Ishpeming Mines)	997,520	24,752,424
Empire	28,634	345,366
Imperial	37,542	636,533
Jackson	1,519	4,029,833
Lake Angeline	104,357	8,950,359
Lake Superior	203,964	15,831,604
Lloyd	135,746	208,216
Lucy	2,025	622,110
Maas	170,705	670,595
Mary Charlotte	264,120	2,123,061
Milwaukee-Davis	10,412	515,898
Mitchell	15,970	114,794
Morris	18,394	19,680
Negaunee	326,877	4,924,546
Princeton	53,476	1,604,778
Queen Group	298,504	7,170,635
Republic	137,063	6,751,142
Richmond	138,394	1,088,761
Rolling Mill	163,286	1,069,764
Stegmiller	45,431	230,227
Stephenson	96,279	788,198
Volunteer	47,698	1,527,143
Washington	60,581	352,032
Shipped prior to 1913 by mines now idle		12,736,192
Totals	3,966,680	107,298,821

LAKE SUPERIOR IRON ORE SHIPMENTS FROM THE DIFFERENT RANGES FOR YEARS PRIOR TO 1910, 1910, 1911, 1912 AND 1913, AND GRAND TOTAL FROM 1855 TO 1913, INCLUSIVE.

(Compiled from Report Published by Iron Trade Review.)

		Prior to 1910.	1910.	1911.	1912.	1913.	Grand Total.
Marquette Range	(Tons......	91,903,982	4,392,726	2,833,116	4,202,308	3,966,680	107,298,812
	(Per cent	20.5	10.1	8.6	8.7	7.9	17.1
Menominee Range	(Tons......	71,213,055	4,237,738	3,911,174	4,711,440	4,965,604	89,039,011
	(Per cent	15 8	9.9	11.9	9.8	9.9	14.3
Vermilion Range	(Tons......	29,125,385	1,203,177	1,088,930	1,844,981	1,566,600	34,829,073
	(Per cent	6.5	2.6	3.4	3.8	3.1	5 6
Gogebic Range	(Tons......	60,820,503	4,315,314	2,603,318	5,006,266	4,531,558	77,276,959
	(Per cent	13.5	10.0	8.0	10.4	9.2	12.4
Mesabi Range	(Tons......	195,724,624	29,201,760	22,093,532	32,047,409	34,038,643	313,105.968
	(Per cent	43.5	67.2	67.4	66.5	68.1	50.2
Cuyuna Range	(Tons......			147,431	305,111	733,021	1,185,563
	(Per cent			.4	.6	1.5	.2
Miscellaneous	(Tons......	880,627	91,682	115,629	104,031	145,010	1,336,979
	(Per cent	.2	.2	.2	.2	.3	.2
	Total tons.	449,668,176	43,442,397	32,793,130	48,221,546	49,947,116	624,072,365
			Increase Over 1909 2.0%	Decrease from 1910 24.5%	Increase Over 1911 47.0%	Increase Over 1912 3.45%	

BIOGRAPHICAL

James B. Cooper.

Born at Springwells, which is now a part of the City of Detroit, in 1859. He was a son of James R. Cooper. Received his early education in the public schools of Detroit, being graduated in 1877. He left shortly after for Hancock, Michigan, to take a position with the old Detroit & Lake Superior Copper Company at its smelter. His father had preceded him to the copper country several years before to assume the management of the smelter at Hancock. The elder Cooper was one of the world's greatest copper smelters and the son followed in the paths of his father.

After two years' work at the smelter, James B. Cooper decided to increase his technical knowledge and spent one year at the University of Rochester, N. Y., returning to the Hancock smelter, where he held the position of foreman until 1888. In that year his standing as a smelterman was recognized and he was placed in charge of the old Parrott smelter at Bridgeport, Conn. In 1890 he returned to the copper country to assume the management of the Calumet & Hecla smelter at South Lake Linden, now Hubbell, where he resided continuously until his death.

Mr. James B. Cooper was one of the authorities on copper smelting of this country and he worked incessantly to get his product on the market in a degree of fineness that could not be approached by the copper of competitors. The excellence of his refining methods had much to do with giving Lake copper the reputation it bears.

He was married in 1892 to Miss Antoinette Senter, a daughter of the late John Senter of Houghton.

He died at Hubbell, Mich., Feb. 27, 1914.

Frank D. Mead.

Born at Ann Arbor, Michigan, January 27, 1856. He attended the public schools of that city, and was graduated from the University of Michigan with the degree of Bachelor of Arts in 1877. In that year he entered the office of Chandler Grant, in Houghton, to take up the study of law, being admitted to the bar in 1881. He was associated for a short time with John Q. Adams, at Negaunee, then moved to Escanaba to engage in practice.

For thirty-three years he was prominent in the business, social, educational and political life of Escanaba. Being one of the best known attorneys of the upper peninsula he had a large practice and represented many of the large business interests of Escanaba and vicinity. He was attorney for the Chicago & Northwestern Railway Company, Minneapolis, St. Paul & Sault Ste. Marie Railway Company, and the Escanaba & Lake Superior Railway Company, at the time of his death. He was a delegate to the Republican National convention in St. Louis, and one of the delegates who framed the new Michigan Constitution in 1908.

He died at his home in Escanaba on February 20, 1914.

ALFRED MEADS.

Born at Brighton, County of Sussex, England, on January 8, 1831. Came to the Upper Peninsula of Michigan in 1859, locating at Ontonagon. He started work as a watchmaker and jeweler at that place. In 1869 he purchased the plant of the Ontonagon Miner, which he published for a number of years. He had the greatest faith in Ontonagon county and the upper peninsula and never failed to express his views through the columns of his paper. He served as deputy collector of internal revenue and collector of customs for the government and was elected probate judge of the county for several terms.

In 1895, when Ontonagon was badly damaged by fire, Mr. Meads moved to Marquette, where he continued to reside until his death on June 27, 1914.

JAMES WOOD.

Born in Glengarry, Canada, in 1849. One of five brothers who came to the upper peninsula and were prominently identified with the iron industry in the early days. They were pioneer explorers on the three Michigan iron ranges, the Menominee, Marquette and Gogebic.

James Wood was the discoverer of the Norrie mine at Ironwood, exposing for the holder of the lease, A. L. Norrie, what turned out to be one of the greatest bodies of high grade ore ever found in Michigan. The North Norrie, East Norrie, Aurora, Pabst and Newport mines being opened on ore measures which were extensions of the find made by Mr. Wood.

The "wood" in Ironwood came from James Wood's name. The Milwaukee, Lake Shore & Western railway (now the Ashland division of the Chicago & Northwestern system) had just completed its rails to that section, and the president of the road and other officials had arrived at the new mining town on the range, when it was learned that no name had been given to the place. James Wood was sent for by the president of the road, and as he was observed coming down the trail, it was noticed that his hands were covered with the stain of the Norrie hematite, and so it was decided then and there to christen the new town "Iron-Wood." The hyphen was later dropped and the name changed to Ironwood.

Mr. Wood journeyed to the southwest several years ago, where he died in February, 1914.

Nathaniel Hibbert.

Captain Nathaniel Hibbert was born in England in March, 1844. He came to America in his early life, later going to Ironwood, Michigan in 1885, where he became superintendent of the Aurora mine. He opened up that mine in such a way as to make it one of the most successful ventures in the Gogebic Range in the early days.

He was president of the village of Ironwood and was its first mayor when it became incorporated as a city in 1888. He served two terms as mayor, leaving the city in 1890 to go to Waynesboro, Virginia, to take charge of mining properties at that point.

He died there in April, 1914.

William B. Linsley.

Born in Meridan, Conn., June 12, 1845. Received his early education in the schools of that city and worked there until he reached the age of 24 years.

In 1869 Mr. Linsley took up his residence in Escanaba, Mich., entering the employ of the Chicago & Northwestern Railway Company as clerk in the local freight office. Later he was promoted to the position of agent, a position he filled until 1876 when he was promoted to the office of division superintendent of the Peninsula division. Mr. Linsley was division superintendent for 36 years and one of the best known of the railroad men in the Lake Superior district.

On April 1, 1912, Mr. Linsley retired from active railroad work and was made resident superintendent of the Northwestern company's tie preserving plant at Escanaba. Shortly after assuming his new duties his health began to fail him, and he was obliged to spend a great deal of his time away from the upper peninsula.

He died at his home in Escanaba on January 16, 1914, at the age of 69 years.

Joseph Sellwood.

Joseph Sellwood was born December 5, 1846 in Cornwall, England. At the age of nine he commenced working as a miner's helper in the East Poole tin mine. At the age of fourteen he became so proficient in the use of the hand tools of his craft that he was given adult wages. At about the age of nineteen he emigrated to America and commenced his work in the new world as a miner in the Mount Hope mine of New Jersey. Remaining there less than six months he came in 1865 to the State of Michigan and obtained work at the old Ogema mine, now a part of the Mass mine in Ontonagon county, Mich.

He remained in the Copper Country until August 1, 1870, when he went to the New York mine at Ishpeming, Mich. Shortly after going to Ishpeming he commenced contracting for mining of the ores in the New York and Cleveland mines. He also started a general store under the name of Jos. Sellwood & Co., which is still being successfully run.

In 1885 Mather, Morse & Co. sent Mr. Sellwood to the then new Gogebic range, to open up the Colby mine (the first mine to be opened on that range) at what is now Bessemer, Mich. In 1885 Mr. Sellwood opened the Brotherton mine at Wakefield for Pickands, Mather & Co., who sold the mine in 1886 to a company of which Mr. Sellwood was president. This ownership continued until the property was sold to Lackawanna Steel Company. Later in 1898 Mr. Sellwood received a lease on the Sunday Lake mine, which property he operated with the Brotherton until the sale of the Brotherton to Lackawanna Steel Company.

In 1886 Mr. Sellwood went to the Vermilion range in

Minnesota and secured for the Chicago and Minnesota Ore Company a three-quarter interest in the Chandler mine then just discovered. For a time he divided his attention between the Gogebic and Vermilion ranges. During the year 1888 Mr. Sellwood moved to Duluth to live. He remained with the Chandler Iron Company until 1892, becoming at that time interested in the development of the Mesaba range.

In 1898 Mr. Sellwood became associated with the American Steel & Wire Company, then controlled by John W. Gates, and assumed charge of their iron ore properties, continuing with them until the formation of the U. S. Steel Corporation in 1901. He then became associated with many interests outside of the Steel Corporation, among which were the Cherry Valley Iron Company, the Wheeling Steel & Iron Company, the Central Iron & Steel Co., and the Salem Iron & Steel Co. Later he took charge of the mines of the International Harvester Company.

Mr. Sellwood also had wide banking interests, being president of the City National Bank of Duluth, First National Bank of Ely, First National Bank of Two Harbors and a large interest with the First National Bank of Bessemer, Michigan. Throughout his life he had an active interest in politics wherever he lived.

Mr. Sellwood combined in his character a strong personality, with a cheerful disposition and a kindly nature that brought to him a large circle of friends throughout the Lake Superior region.

He died February 24, 1914, at his home in Duluth, Minnesota.

JOHN H. TAYLOR.

Born in County Londenderry, Ireland, May 27, 1830, of Scotch parents. He left the old country and came to the United States in May, 1846, finding employment in a factory at New Bedford, Mass. He remained in the Eastern states until 1861, during which year he moved to Houghton, Michigan, where he obtained employment as a laborer at the Quincy mine, later moving to the Isle Royale mine at Houghton where he was employed as surface foreman until 1869, when the mine shut down. He then moved to Ishpeming, where he was captain of the New York mine until 1872. He then spent two years in Colorado, Utah and Nevada, returning in 1874 to become mining captain at the Commonwealth mine until 1883. During the next two years Captain Taylor was superintendent of the Great Western mine at Crystal Falls, and left there going to Ironwood, Michigan, in May, 1885, as mining captain of the Ashland mine, afterward becoming its superintendent in 1891. He shipped the first ore over the Ashland docks that came from Ironwood, and sunk the first operating shaft in the town. He remained as superintendent of the Ashland until 1894 when the mine closed down.

He was appointed as inspector of mines of Gogebic county in 1896, resigning that position in 1907, on account of illness.

He died at his home in Fond du Lac, Wisconsin, December 13, 1913.

APPENDIX

THE EARLY HISTORY OF THE MARQUETTE IRON ORE RANGE.

(PREPARED FOR PROGRAM FOR THIS MEETING.)

BY GEO. A. NEWETT, ISHPEMING, MICH.*

It was more than two hundred and fifty years ago that copper was found on the shores of Lake Superior by the Jesuit Fathers, those hardy Frenchmen who navigated the lake in frail canoes in the interest of religion and mankind generally. They noted the copper along the shores of the lake and at Isle Royale, where, at that time, the Indians were taking copper from the lodes as well as from the water along the shores. Copper was attractive to the Indians who used it as ornaments, cooking utensils, and for other purposes. It was native copper, malleable and easily shaped to forms they desired. It was the metal sought for. Iron, had it been found, would have been in the form of an ore and of little use to the Indians who probably knew nothing of how to smelt and refine it. Besides iron ore was not found along the shores of the lake, nor has it since been located within several miles of this great body of water. The early voyageurs evidently did not proceed far inland, confining their examinations to the locations inhabited by the Indians, these being near the shore of the lake. Progress into the interior of the country would have been difficult owing to the dense growth of timber and underbrush, and the reports of the Indians were evidently accepted concerning the minerals, woods, streams, and other points in which the early explorers would naturally have been interested.

The first authentic information concerning the existence of iron ore in this region came from a party of surveyors under direction of Dr. Douglass Houghton, who was the first geologist for the State of Michigan. Dr. Houghton first visited the Lake Superior country in 1830 in company with Gen-

*Editor "Iron Ore".

eral Cass. He returned in 1840 as State geologist and made a report to the State legislature the following year on his findings, this creating great interest in this portion of the State. In the year 1844 Dr. Houghton was given a contract by the State to make the linear surveys of the lands bordering the lake, along its south shore, which he was to combine with the geological survey. In the fall of 1845, while engaged in this work his boat was capsized off Keweenaw Point, and he was drowned.

Today there is being erected, by the Keweenaw Historical Society, on the shore near the spot where his body was recovered, a monument to his memory, a tardy but affectionate action by those who appreciate the great work he did, his indomitable courage and his general ability.

Assisting Dr. Houghton were Messrs. Wm. A. Burt, Bela Hubbard, C. C. Douglass, Wm. Ives, S. W. Hill, Jacob Houghton, Jr., and Mr. Higgins.

When Dr. Houghton was granted the contract for the survey referred to in the foregoing, he deputized Mr. Burt to take charge of the field work, giving him the entire allowance voted by the legislature for the work. It was while engaged in this task, in 1844, that Mr. Burt with a party consisting of Jacob Houghton, William Ives, R. S. Mellen, Harvey Mellen, James King and two Indians named Doner and Taylor that the first iron ore in the Lake Superior region was found. They were camped at the east end of Teal Lake, now located in the corporate limits of the City of Negaunee, and on the morning of the 19th of September while engaged in running the line south between ranges 26 and 27 Mr. Ives, who was compassman, observed strange fluctuations of the needle. He called the attention of Mr. Burt to the needle's variations. Mr. Burt, who was the inventor of the solar compass, at once took occasion to illustrate the troubles that would have been encountered were it not for his invention.

This same compass, by-the-way, is now the property of Mr. Addison Cole, of the City of Marquette, Michigan, and will be exhibited to members of the Institute through the courtesy of its present owner.

When, at one point, the needle of the compass showed a wonderfully great variation, Mr. Burt instructed the members of the party to look about to learn what caused it. They left the line and began searching, with the result that many specimens of iron ore were found. The party took many specimens into their camp, recording the discovery. The Jackson mine was afterward opened near the location where these specimens were picked up. The Jackson ores are not magnetic, and the specimens found, or some of them, at least, were probably "float."

The Jackson mine was the first to be opened in the Lake Superior country and there appears in this program an engraving showing the spot where the first ore in this region was found. A monument has been erected to mark the place, it being erected by the Cleveland-Cliffs Iron company, the present owner of the lands holding the old Jackson mine. So that to Mr. Wm. A. Burt and party the credit belongs for the finding of the ore which led to the opening of the initial mine in this region and from which a wonderful industry has grown.

The following year, in June, 1845, Dr. Douglass Houghton and Mr. Burt, while subdividing town 47 north, range 26 west, paid much attention to an ore showing at the corner of sections 29, 30, 31 and 32, where the Palmer mine, of the Cascade range was since opened.

There may have been some knowledge of these ore outcroppings by the Indians, but if they did know about them they did not consider them of any value. At any rate the party of surveyors are entitled to the credit of first bringing the fact of the existence of iron ores to the attention of the people of the State and country.

It was in June, 1845, that the first company was organized to explore for minerals on the south shore of Lake Superior, this being formed at Jackson, Michigan. Abram V. Berry was president; Frederick W. Kirkland, secretary, Philo M. Everett, treasurer, and Geo. W. Carr and Wm. A. Ernst, trustees. On July 23 of that year, the same day the articles of association were completed, a party consisting of Messrs. P. M. Everett, S. T. Carr, W. H. Monroe and E. S. Rockwell started for Lake Superior and secured what is now the property on which the Jackson mine is located. The lands were obtained through permits.

In August of 1846 the first iron made from Lake Superior iron ore was produced by Mr. Olds of Cucush Prairie, who owned a forge at that place and was making iron from bog ore. The forge was out of commission at this particular time and he put the ore in a blacksmith's forge, drawing out what was called a fine bar of iron.

The first iron made on Lake Superior was produced from a forge located about three miles east of the present City of Negaunee, on the Carp River. Work on this forge was begun in 1847, and the first iron bloom was made on the 10th day of February, 1848, the forgeman being Ariel N. Barney.

Mr. Barney was noted in those days. He built the first hotel in Marquette, was one of the first justices of the peace, an office he held many years, and was afterwards elected to the positions of clerk and register and judge of probate. He served as a private soldier in the war of the rebellion, and was one of the sturdiest of the pioneers of those days.

The Jackson forge was naturally of primitive kind. The power was supplied by the Carp River across which a dam was constructed, giving an eighteen-foot head of water. There were eight fires from each of which a lump was taken every six hours, placed under the hammer and forged into blooms four inches square and two feet long. The product per day was about three tons. It required two six-horse teams to draw this iron to the mouth of the Carp over the worst road imaginable, and a great contrast to the macadamed highway which now practically follows the old route. The machinery for the forge was made at Jackson, Michigan and, with the supplies, etc., was shipped by rail to Detroit, from there by boat to Sault Ste. Marie where it was re-shipped in the steamer "Independence" to Marquette, arriving there in July, 1847. Mr. Barney and his son Samuel accompanied the shipment. There was no wharf at Marquette and the cargo was taken ashore in small boats and pulled twenty feet up the bank. The cattle were pushed into the water and swam ashore. To transfer the machinery to the forge location was no small task. The road was an Indian trail. The distance was twelve miles, with many hills and some swamps on the route. It was a heart-breaking job, but Barney finally accomplished it, and the forge was completed and went into action at the time stated. The ore was hauled to the forge location on "jumpers," being pulled three miles. It was ore picked upon surface, there being plenty in this form for the needs of the plant.

Soon after the forge was completed a freshet carried away the dam, this accident closing the forge for a time. In the summer of 1848, when Mr. Everett came up to inspect it, it was repaired, and the manufacture of blooms continued.

The first bar of iron made from this forge was sold to E. B. Ward, of Marquette, and from it was made the walking beam of the side-wheel steamer "Ocean."

The Jackson forge was kept active until 1854 when it was finally abandoned, having proved a failure financially, but it established the fact that the iron of Lake Superior was high grade, popularizing it with consumers demanding the best.

During the last four years of its activity it was leased by the company to several parties. B. F. Eaton of Columbus, Ohio, was ruined by it financially in less than six months. Those were not the days of big business, or of great combinations of wealth. Eaton was succeeded by the Clinton Iron company, an association of forgemen from Clinton, New York. Of this company a member was Azel Lathrop, who for many years thereafter, resided at Lathrop, on the line of the Chicago & Northwestern railway, Peninsula division. He was father-in-law of Mr. J. H. Malloy, of Ishpeming. He had been employed at the forge for some time. The price of blooms was low, not meeting the cost of production, and the company gave up the lease after a short trial. The late Hon. Peter White then took hold of the forge, but could not make it win, and surrendered the lease to the owners of the plant. J. P. Pendill, of Marquette, was the last to operate it, and he retired soon after taking hold, it failing to prove profitable even under his energy.

Thus is briefly recited some of the principal incidents in connection with the making of the first iron on Lake Superior from the ores of this region. On the site of the old forge the Cleveland-Cliffs company has erected a monument and tablet which tells of the building of the forge. A reproduction of it is presented in this program and will be interesting to the members of the Institute by reason of its association with the iron-making industry.

In March, 1849, the Marquette Iron company was organized. Its members were A. R. Harlow, W. A. Fisher, E. B. Clark and Robert J. Graveraet. They built a forge at Marquette at a point a little south of what is now known as Baraga avenue. Like the Jackson it was a disappointment financially.

The Collins Iron company built a forge in 1855 on Dead River, three miles from Marquette, it being known as the "Collinsville."

The Marquette forge went into commission in the summer of 1850, but a very severe winter, in which the snows were heavy, prevented the hauling of ore from the Cleveland mine, at what is now the City of Ishpeming, and the small amount that had been secured from the Jackson mine in the fall was soon exhausted, so the forge had to cease operations for a part of the year from lack of ore. There was also trouble in keeping enough charcoal on hand for the use of the forge, the coal being secured from local kilns. The wood was charred in pits in those days, and the old scars, showing where they were located are numerous in this section. The ore was hauled to Marquette and crushed for the forge, it being all of the hard variety in those days, no soft ores then being mined, nor were they considered of any value. When all the costs were figured, including the shipping to Pittsburg, the ton of blooms laid down at that point represented an actual value of about $200. The blooms sold for $80 per ton. This tells the story of why the forge business never grew to anything like large proportions.

With the failure of the forges it was evident that the mining and shipping of ore must be the industry developed in connection with this mining region, but to bring this about there would have to be better means of transportation. On August 21, 1852, an act was passed by congress granting the State of Michigan 750,000 acres of land for the purpose of building a canal at Sault Ste. Marie, on the St. Mary's river. From that small beginning this canal is now the greatest in the handling of tonnages and values of any in the world. A railroad was constructed to the mines from Marquette, and cargoes were taken down the lakes in schooners, the loading being done by wheelbarrows. It took four days to load a schooner with 400 tons, and the unloading at lower lake ports took longer. It was necessary, in the latter task, to build stagings in the holds of the schooners on which the ore in the bottom of the vessel was shoveled. From the staging it was lifted to the deck, and from the deck taken ashore in wheelbarrows. In 1858 the Cleveland Mining Company constructed nine or ten ore pockets at the Marquette dock, the first to be built.

Instead of the little wooden schooners of the fifties we now have leviathan steel boats that take on 12,000 to 15,000 or more tons and that are loaded and discharged in a few hours. The mule teams pulling ore over a tramway are supplanted by steam locomotives, and the little wooden jimmy cars of the railroads of the early days, that held from 4 to 6 tons have been replaced with those of steel that carry 50 or more tons. From the annual shipment of a few hundred tons the Lake Superior region has swelled its output to the enormous tonnage of more than fifty millions.

The old-time docks of wood have been replaced with fireproof, rigid construction of steel and concrete, a fine example of which the members of the Institute will see at Marquette in a recently built dock of the L. S. & I. R'y. Co.

The growth of the industry has been steady, and from the modest beginning of the sturdy pioneers a magnificent volume has resulted. Millions upon millions have been invested in mines, and their equipment, in ships and railways to handle the ore from mines to delivery points, model towns and thrifty communities have followed the development of these mines, and from the earth of this region enormous values have resulted and the world has been greatly aided in its civilization and progress due to the mineral operation of this field.

The first ores to be sent out of Lake Superior were shipped in 1850 when a small tonnage was sent to Newcastle, Pa., and were made into blooms. Two years later a considerably larger shipment was made to Sharon, Pa., and melted into pig iron. The first regular shipment to lower ports, consisting of 5,000 tons, was made in 1856. The bloomeries in Marquette county had probably consumed about 25,000 tons before this period.

The bloomeries having been proved failures financially, a trial at pig iron making followed, the first furnace to be erected being the Pioneer, it being put up near the Jackson mine. It made its first iron in July, 1858. The Pioneer Iron Company, by whom this furnace was built was afterward merged into the Iron Cliffs Company which much later was merged with the Cleveland Iron Mining Company under the name of The Cleveland-Cliffs Iron Company.

The Cleveland Iron Company was the second in chronological order to engage actively in iron mining in this region, its articles of association being filed in March, 1853. Its incorporators were John Outhwaite, Morgan L. Hewitt, S. Chamberlain, Samuel L. Mather, Isaac L. Hewitt, and E. M. Clark. Previous to 1855 there were mined 5,000 tons of ore which were treated in local forges. This company, with its additional companies operating under its present title has mined 38,425,862 tons of ore.

The Lake Superior Iron Company, the third to engage in the iron mining business in this region, began work in 1857. It is now one of the properties of the United States Steel Corporation and had mined and shipped up to the close of last year 15,801,870 tons.

Up to and including the year 1913 the Marquette Range had produced 107,298,812 tons of ore.

Its general condition is excellent and it will be an active shipper for many years at the present rate of production. It mines both hard and soft hematites and limonitic ores. Its mines are operated underground with few exceptions, and it has the deepest iron mines in this region. Its development, area, and general structure is generally well known to the members of the Institute, having been much advertised. Being the oldest of the iron ore producing ranges in the Lake Superior district it has long been prominent. It has been a wonderful training school for men engaged in iron ore mining, and its graduates are to be found in all portions of the world where mining is being carried on.

HISTORY OF MARQUETTE ORE DOCKS.

(This narrative is compiled by D. H. Merritt, Marquette, Michigan, from his early recollections.

In the year 1853 Mr. Daniel Merritt (my father) was employed by the Cleveland & Pittsburg Railroad Company building a coal dock in the City of Cleveland, Ohio, near where the present Union Passenger Station is located. His familiarity with dock construction led to having entered into a contract with the late John Senter of Eagle River, Michigan, for the construction of a merchandise dock at that place, which was completed in the fall of 1854. Upon his return to Cleveland, a contract was made with the Cleveland Iron Mining Company (now The Cleveland-Cliffs Iron Company) W. J. Gordon, President, and Samuel L. Mather, Secretary, for the construction of a dock in Marquette Harbor. He left Cleveland as soon as arrangements were completed and arrived in Marquette November 20th, 1854, and began getting timber ready for the dock, which was to be completed as early as possible in 1855. He employed a number of Frenchmen, expert in woodcraft, among whom was one who had contracted the smallpox at Sault Ste. Marie and from whom Mr. Merritt took the disease and died December 20th, 1854.

In company with Mr. James J. St. Clair, Agent for the Cleveland Iron Mining Company, stationed at Marquette, I left Cleveland on the 17th of February, 1855, and met, in Chicago, Mr. David Himrod, the Agent for the Jackson Iron Company, also stationed in Marquette, and a Mr. Jabez Smith, of Sharon, Pennsylvania, arriving in Marquette March 17th, with snow four feet deep on the level. It was the original intention of the above named companies to build and operate a joint dock for the shipping of iron ore, a contract having also been drawn with Mr. Merritt and the Jackson Company which awaited the signature of L. I. Kimball, president of the company, upon the death of Mr. Merritt. There being no existing contract with the Jackson Iron Company, the project for building and operating a joint dock was abandoned and each company decided to build a separate dock, whereupon Mr. Smith began the construction of a dock for the Jackson Company which was located on the north side and parallel with the shore of the bay and finished during that year. It was reached by a wooden trestle extending from the east end of Washington street to the west end of the dock, gradually decreasing in height until it was about eight feet higher than the floor of the dock upon which the ore was unloaded and which floor was about four and one-half feet above the level of the water, making the entire height of the dock and trestle about twelve and one half feet. The ore was delivered upon four wheeled cars drawn by mules from the mine, making one trip per day and containing about three tons per car, which was unloaded with shovels and thrown upon the floor of the dock from which it was placed into wheelbarrows and wheeled aboard the vessel. There were employed from 20 to 30 men and barrows requiring from three to five or even six days to load a cargo of 200 to 300 tons, the latter being the largest capacity of vessels employed in the ore trade at that time. A suggestion of one of the vessel captains that the trestle be made three or four feet higher and located on the edge of the dock instead of the center, as at present, the ore could be unloaded from the cars into chutes and thereby save one handling and insure greater dispatch.

The dock for the Cleveland Iron Mining Company was built by Alexander G. Ross and Captain Joseph Bridges during the year 1855 and instead of a trestle as in the case of the Jackson dock the cars were run onto the level dock and the ore wheeled aboard the vessel in the same manner as employed by the Jackson Company.

Upon the completion of the Iron Mountain railroad in 1857 by the late Heman B. Ely, extending from Marquette to the Lake Superior mine (now Ishpeming) the mule transportation was abandoned in 1858 and the ore from the three mines was carried by the Iron Mountain Railroad Company.

In 1857 the Lake Superior Iron Company with Samuel P. Ely as agent and resident director of the railroad company, constructed a dock from the east end of Main street into the bay, of a capacity of 75 pockets which was the result of the vessel captain's suggestion, modified and enlarged upon by reason of the question what was to be done with the ore when there were no vessels in port as it would be impracticable to allow the cars to stand idle, sometimes for days, awaiting the arrival of vessels. It was therefore decided to build the dock 25 feet high and to build pockets for the reception of the ore. The height of the proposed dock was objected to by the vessel captains upon the ground that the ore falling from so great a height would be liable to damage the vessel and possibly sink it. This was however overcome and the dock constructed with pockets as proposed, being the first pocket dock ever built for handling iron ore. In 1858 the Cleveland Iron Mining Company, noting the success of the Lake Superior Company's dock, erected a trestle and pockets upon the dock built by Ross and Bridges in 1855, making, however, the trestle 30 feet above the lake level but keeping the same height as at the Lake Superior dock at the mouth of the pocket, thereby making a greater storage capacity by five feet than that of the Lake Superior dock. After the completion of the Cleveland Company's 100-pocket dock by the late Jay C. Morse, Agent, it was considered that sufficient dock capacity had been provided for a number of years but the increased consumption of Lake Superior ores and enlargement of vessels rendered it necessary to provide greater dock and storage capacity. Accordingly, the railroad company constructed a dock in 1864 upon the present site of No. 5 dock. Vessels carrying 1,000 tons had made their appearance and in order to give sufficient angle to the chutes the mouth of the pockets required raising which was done, increasing the height of trestle to 35 feet and a corresponding increase in the height of pockets. Meanwhile new mines were

ERRATUM

Page 307, sixth line from bottom, years shown as "(1895 and 1896)" should be omitted.

southern point of Presque Isle. In 1890 the D., S. S. & A. R. R. company constructed a dock from the east end of Washington street just south of the approach to the old Jackson dock known as No. 4. It was 47 feet high, 27 feet from the mouth of pockets to the water and contained 200 pockets with a storage capacity of 28,000 tons. The superstructure is now (1895 and 1896), being taken down. In 1896 and 1897 The Cleveland-Cliffs Iron Company, Wm. G. Mather, President, built the Lake Superior and Ishpeming Railroad and constructed a dock in Presque Isle bay under the general supervision of Robert Selden Rose, constructing engineer. This dock was 54 feet high and contained 200 pockets with a storage capacity of 36,000 tons and was considered equal, if not superior, to any in existence. It was operated until 1913. In 1905 and 1906 a new dock known as No. 5 was built by the D., S. S. & A. R. R. company in Marquette bay on the site of No. 2, the approach to which is by a steel bridge over Front street, thereby obtaining a height of 71 feet above the lake level. It contains 200 pockets, 40 feet from mouth of pocket to water level, and has a storage capacity of 45,000 tons. It is now operated and over which all ore transported by that company is loaded into barges, the early sailing vessels having long since gone out of existence. In 1911 and 1912 the Lake Superior and Ishpeming Railroad Company constructed a concrete dock in Presque Isle bay under a contract with the Raymond Concrete Pile Company and Wisconsin Bridge & Iron Company. It is 75 feet high and contains 200 pockets, 43 feet from mouth of pocket to the water. It has a storage capacity of 50,000 tons. Six thousand three hundred tons of hematite ore has been loaded into a 6,500 ton barge in one hour and 15 minutes, 84 tons per minute. Also 3,850 tons hard ore in 23 minutes equal to 165 tons per minute. The average loading time during the season of 1913 was 1,527 tons per hour. The ore is delivered in 50 ton cars, a single locomotive hauling 45 cars of a capacity of 50 tons each. This dock is acknowledged to be the best in the world and will well repay a visit to those interested.

A TRIP TO LAKE SUPERIOR.

(The following narrative of "A trip to Lake Superior" is furnished us by William Kelly, Vulcan, Mich., and was written by his father, Robert Kelly, and published in the New York Evening Post, Sept. 8th, 1853.)

Although persons are visiting this region every day, and the road to fortune by the way of the copper mines has become as familiar to some as any beaten highway, a recent journey in that quarter was full of novelty to me, and a brief sketch of it may, in like manner, interest others.

Imagine us, then, embarked at Detroit on board the steamboat Northerner, bound for Mackinaw and Saut Sainte Marie. A lovely June afternoon smiled upon us as we passed up Detroit River and across Lake St. Clair, and a bright moon silvered our track as we glided through the beautiful St. Clair river. The gaiety within the cabin, where dancing and negro minstrelsy were the order of the evening, according to custom on these waters, served to amuse and excite, while the calmness and beauty of the scene without exercised a more tranquilizing influence.

Early morning found us opposite Saginaw bay, and the swell which gently heaved our boat indicated that we were opposite to that spot in its deep recesses where Aeolus is said to often hold his court. We pursued our voyage in solitude during almost the entire day. This seemed in keeping with the character of Lake Huron, a forest-girdled lake, as for the most part, it is. A propeller passed near us in the afternoon, as we approached Bobolo Islands, on her way to Mackinaw. Soon after, our attention was arrested by fragments of a vessel floating upon the waves—timbers, casks, barrels, pieces of painted board, and finally a complete upper deck, with its sky-lights giving evidence that some disaster had recently occurred. The imagination of some of our passengers portrayed men afloat on pieces of the wreck; but the practiced vision of the seamen, and the eye of the captain, aided by his telescope, could not discern any living object. We were informed after arriving at Mackinaw, that two propellers had left in the morning, bound down. One was a new boat, named the Congress, and her people had spread through the town a rumor that she intended to beat the Bucephalus. We did not ascertain till a week later the particulars of the disaster. The boiler of the Congress exploded, killing instantly five men employed near the engine. The rest of the crew, the captain, with his family, and fifteen passengers, were picked up by the other propeller, and by a schooner which was at the time near the scene of the catastrophe. The hull of the Congress went down in five minutes after the explosion.

SAUT SAINTE MARIE.

The next morning we landed at the Soo. Now what shall be done for a decent name to this place? It is too much to expect that people will learn to utter the beautiful full French name Saut Sainte Marie. I was, no doubt, set down at once as a stranger in those parts, because I ventured to pronounce it correctly. But I could not be coaxed to say Soo. It is too insignificant and barbarous a travesty; So is little better. And the prospect of the future importance of the town renders the subject of its name a matter worth consideration. Perhaps some "compromise" may be hit upon and generally accepted. The place is now one of considerable activity, and boasts of two houses of entertainment—I beg pardon, hotels—where travelers are made comfortable.

A day at Saut Ste. Marie can be passed very pleasantly. A jump (saut) down the rapids in an Indian canoe, for those who like it—fishing for speckled trout at the mouths of the streams which come in on the Canadian side, or even off the steamboat dock above the portage—the Indians speaking in that strange recitative, mingled of softly-sweet sounds and cadences, with nasal, punchinella-like tones or lounging in the luxury of idleness, or playing marbles in the streets, or taking whitefish in the rapids—and the excavation of the grand ship canal recently commenced, constitute the objects of attraction.

The Indian process of taking fish in the boiling rapids is peculiarly interesting. Without waiting for wind or tide, they pull out from the shore at any time when they wish to catch a meal or to earn a few shillings, (a shilling and a whitefish are convertible terms in the upper country). The boats are sharp at both ends, made without keel, framed of light slats of flexible wood running both longitudinally and transversely, and covered with bark. One Indian stands erect in the bow, and the other in the stern. This attitude they maintain, however violent their exertion. The skill and ease with which they manage the canoe are a wonder to behold. The man at the stern with a scarcely perceptible motion of his paddle, holds it steadily in its place, with its head up stream. The other is watching for the fish which, with their head also against the current, love to poise themselves in the swiftly-rustling waters, motionless as the two-finned canoe that holds its pursuers. As soon as he spies one within reach, he plies a scoop net of large size, with which he is armed and in an instant the fish is in the boat, his companion giving it a quick impulse at the right moment, and arresting it in an instant.

No wonder the Indians love the Saut. The stupendous fish preserves of the luxurious Romans are not worthy to be compared with this inexhaustible living preserve. The shore of the stream opposite was specially reserved by the Indians in their treaty with the United States. It was worth a whole territory of land to them. Here was their village, the huts strewn along in sight of the fishing ground and the canoes drawn up on the shore. But the route for the ship canal was surveyed directly through the village, and without any consent given on their part, or any arrangement as to compensation, they have been obliged to decamp. The site was wanted for the business communications of a great nation, and why should the savages' paltry uses of the spot be allowed to stand in the way of progress and civilization? They will undoubtedly receive compensation for the loss sustained. Their respectable chief, Shawano, will plead their cause before their great father, who will do them justice. But the indemnity will soon disappear, in a few years the remnant of the tribe will wander off or melt away, and their exciting chasse aux poissons will become a matter of tradition!

THE SHIP CANAL.

A large force, composed chiefly of Germans, is at work upon the canal. Huge boulders lie uncovered in the trench or scattered about upon the ground, in wilder disorder than they were left as deposited by those mighty currents, of which geologists tell us that they rounded them like pebbles. The gangs wheel their barrows in Indian files, but no Indian is in their ranks. If he had no repugnance for such dull labor as white men do, he would scarcely be an accomplice in diverting any portion of the laughing, roaring, dancing waters of the Saut, into this artificial channel. It is nothing to him, that it is the link which will bind all the great lakes together in one unbroken chain of navigation, making them, like the states which encircle them, united and one. It will be no pleasure to him to see palatial steamers passing through it—as they will a year or two hence. There is every reason to believe, from the energy and capital enlisted in the prosecution of the work, it will be completed next year.

It is a work of magnitude simply, magnificent in its dimensions, in the character of the structure, and in its purposes; but in no sense one of difficulty. The wonder will soon be why a work so easily accomplished was delayed so long. The distance does not exceed a mile, and it is almost a perfect level. The rock lies at the depth of a few feet, but is easily excavated. Unfortunately, it does not furnish stone of the proper solidity for the construction of the locks, of which there are two—one with a rise of 10 feet and the other of 11 feet, the whole difference in level to be overcome. These constitute the great features of the whole work, being of enormous size, 350 feet long by 60 feet wide, and required to be of the very best construction that engineering science could frame specifications for.

The Saut Sainte Marie Canal Company was incorporated by the legislature of the State of Michigan at the last session. They advance all the capital that may be necessary, and when the work is completed, according to specifications, they will become the owners of half a million acres of the public lands, appropriated by Congress to the State of Michigan for the construction of the canal. The idea was, perhaps, that the work would be constructed with the property of the government, but the question of constitutionality would be avoided as a direct issue. The State of Michigan has transferred the task, and her rights to the lands, to the company she has incorporated. They have, it is understood, the privilege of indicating in advance the sections which they wish to secure, and have actually, as the first step, marked every unentered section of land in the upper peninsula of Michigan, good, bad, and indifferent, amounting to something less than two hundred thousand acres.

All the mineral treasures that may be discovered hereafter in this territory, will be theirs. The general expectation is, that a large profit will be realized by the company, and they will have earned it fairly. But is not this a portentous monopoly of lands and mines! The vast gifts of lands to private corporations that have been made within a few years past, will, at no distant day, excite the astonishment of the nation. It is to be hoped that the breaking down of the barriers of the constitution as to internal improvements, by the general government, will be arrested, if it be only to put a stop to this anti-democratic disposition of the public lands, and to guard against the important social consequences which will result from it.

THE GREAT LAKE.

There are, at present, three passenger boats upon Lake Superior, the steamers Sam Ward and Baltimore, and the propeller Manhattan, affording as comfortable accommodations as could be expected. Our party took passage in the Manhattan, for Marquette, the first town upon the lake, about one hundred and fifty miles distant from the Saut. The Pictured Rocks lay directly upon our route, and as we were to pass on the inside of Grand Island, we expected a very near view, but, unfortunately, went by them during the few hours of night. The passage around Grand Island afforded us some compensation for our disappointment. The banks are highly diversified in surface, picturesque in outline and finely wooded down to the shore. We were charmed to enter the smooth river-like strait from the rough sea, on which we had been tossing and suffering. The passage is several miles in length and sheltered from all winds. The lands on both sides belong to a single family, who are delightfully situated and fully appreciate the wild paradise, in which their lot is cast. Fish and game abound, in great variety and excellent in quality. The land bears grass luxuriantly for pasturage, and is easily cultivated. They have a grist and saw mill, and carry on a considerable traffic with the Indians for beaver and castor skins.

We landed on the innermost corner of Grand Island for the purpose of discharging freight and receiving wood, the boat being stranded gently on the sandy beach. We passed two or three hours rambling about, collecting wild flowers and specimens of plants and trees that were new to us, and searching along the margin of the water for handsome pebbles and for stray agates, if any should present themselves. But they are not found in this part of Lake Superior. Agate Bay was a famous locality for them in times past, and they are said to abound upon the northern shore. Our voyage out of the passage, after re-embarking, was equally beautiful with our approach through the narrower entrance. The northwestern part of the island exhibits a bluff of sandstone of the same formation as that of Picture Rocks. A luxuriant growth of trees and shrubbery creeps down the face of the rock, like tresses upon a lovely forehead, and as we receded from it we caught some exquisite dissolving views of airly castles.

VILLAGE OF MARQUETTE.

We arrived at Marquette in the afternoon, a rising village of some three hundred inhabitants, favored with a hotel, a school house, and a church worshipping in the same—nestled in the innermost lap of Iron Bay. For beauty of position it claims precedence over all the towns of Lake Superior. The bay sweeps in a graceful curve, for several miles, until it reaches the embosomed cove which forms the harbor. Directly opposite the entrance a rock rises high above the water, a most picturesque object from the shore. Marquette is the port for an important and extensive iron district, lying south from it at a distance of from twelve to twenty-five miles. This region is as yet almost inaccessible, except in winter, from the want of proper roads. But within a year from this time, probably, a plank road or a railroad will establish an easy and constant communication, bringing the mountain to Marquette and Marquette to the mountain. There is a blast furnace located there, for the manufacture of blooms, erected originally by the Marquette Company, but now owned and kept in operation by the Cleveland Company, their successors. The ore is made into blooms without the intermediate process of running into pigs, and yields the same quantity of blooms per ton as pig iron. There is, besides, a factory for sawing and grinding whetstones, similar to the Turkey oilstones, the quarry lying about eight miles back from the lake.

The harbor is simply as nature formed it, except that a lighthouse sheds its guiding beams from the outermost point of the neck of land, still covered with forest, which protects it on the westerly side. A breakwater at this point is required to complete the harbor, and afford a shelter against storms from the northeast. Nothing has been done, as yet, by the United States government, for the security of vessels on Lake Superior, except the erection of lighthouses at a few points. The vast increase of tonnage which will follow the completion of the ship-canal in progress, will render it a matter of great importance that safe harbors should be provided for the protection of life and property upon this inland sea. Our statesmen find great difficulty in determining the constitutional duties of the general government, as to works of improvements for the benefit and security of navigation, and in defining the boundaries where its powers cease.

Creeks, brooks, and rivulets assume the nomenclature of rivers in order that they may be brought within the supposed limitations of the constitution, and, by a strange political fiction, a river, laving the shores of several states, and receiving the waters of navigable branches, is deemed and taken by some very strict constructions to be a sea. But neither fiction nor hyperbole are requisite for the purpose of placing the harbors of our land-surrounded seas upon the same footing with those upon our Atlantic and Pacific coasts. There is a special necessity for good harbors on the larger lakes—harbors easy of approach, deep enough to enter when heavy billows are rolling, and secure when reached. They offer the only protection when a long and furious storm arises, as there is not sea room for a vessel to stay out and lay to for any length of time. The attention of Congress will be directed to this subject at an early day, and among the harbors which will first claim consideration, is unquestionably that of Marquette.

THE IRON DISTRICT.

The main object of our party in landing at this point, was to visit the iron district. Some others joined us, and when the company was all mustered, it was found to consist of about twenty in number. The resources of the place were put in requisition to equip the expedition, and furnish supplies for several days. Two or three saddle-horses were obtained and two wagons for the conveyance of bedding, stores and baggage, and the transportation of those who felt disposed to undergo the dislocating process of the wheel torture. The major part performed the journey afoot, over a road terribly rough in its best state, and now full of sloughs, by reason of long-continued rains. We established our quarters at Jackson Forge, on the falls of the Carp river, a distance of ten miles from Marquette, converting a small unoccupied and unfurnished house into a forest hotel. The conditions of our lodgment were this, that if we were not satisfied with the accommodations, or were disposed to find fault with the cookery, the attendance, or any part of the service of the establishment, it was ourselves that would catch all blame.

Under these circumstances, we found but little fault either with the fare or the accommodations, distributing among the members of the company the various departments of labor. The neighboring Carp furnished us with trout, a spring some rods distant supplied us with water, and a store of wood was at hand to furnish smoke-fires as our night watches against countless hordes of pestiferous mosquitoes and flies. The incidents and circumstances of that sojourn are already assuming a tint of mellowed interest, which they suggested very faintly at the time. This roughing it is a very pleasant thing as the subject of a narrative, when surrounded by cheerful and refined society, and enjoying all the comforts and luxuries of civilized life, but not quite so interesting while it is a matter of experience.

Daylight peeped at 3 a. m., into the garret where we lay stretched, like a harmonious political convention, upon the same platform, and the sweet twitter of the birds was no unwelcome summons to bid us rise from such a resting-place. We made an early start, and, after a walk of four or five miles over a road similar to that which had tried our patience and our boots the previous day, reached Jackson Iron Mountain. A small part of our way was the shore of Teal Lake, an exquisite mountain lake, some two miles long, by one mile wide—its clear waters bordered with a sandy margin, on which were printed the recent foot-tracks of a herd of deer. We spent several hours in the exploration of Jackson Mountain. The whole smithy of Vulcan, with all his Cyclopean helpers, could never have heaped up and would never exhaust this vast pile of mineral that has been thrown out from Nature's deepest laboratory. The only idea that can be given of it is, that it is a hill of iron-stone, broken into fragments or cracked in seams, three-quarters of a mile long, half a mile wide, and rising to a height of one hundred and fifty feet.

It would be an interesting proposition, for such as choose to undertake it, to calculate from these data the quantity of iron contained in the mass above the surface. One side of the hill is nearly precipitous, showing the iron from top to bottom. The most of it is covered with trees which have found their nourishment in the thin deposit of earthy substances and decayed vegetable matter that, in the lapse of centuries, has been formed over the mineral upheaval. In several places we tore away, with our hands, a matted bed of mosses and leaves, and picked up from beneath fragments of ore with no mark of rust upon them. There are differences in the appearance of specimens obtained from various parts of the moss, but the results of analyses and of working the ore, show that it is singularly uniform throughout in quality and purity. All the ore that has been used at the Jackson Forge, and at the Marquette Forge, was obtained from a single small spot, and from it has been manufactured all the iron known as Lake Superior iron, already celebrated for its remarkable toughness and valuable properties for shafts and axles. It is quarried at very small expense, blasting easily, and breaking up at each blast into convenient fragments, differing in this respect from the mountain masses of Missouri, which are quarried with great difficulty.

SPIRITUALISM.

While engaged in the survey of the Iron Mountain, a heavy shower of rain compelled us to flee for shelter into a hut, occupied by some men who were engaged in cutting shingles and erecting a large log building for the use of workmen. I was surprised to observe that one of the men was reading a monthly magazine. Another of them fancied himself a spiritual medium, and a demand was immediately made upon him for an exhibition of his powers. A spiritual circle was formed, and the usual arrangement of hands and fingers took place upon the massive table of the log cabin. It was, certainly, an extraordinary scene, to occur in the forest of Lake Superior, upon the extreme frontiers of civilization. There seemed to be some confusion of ideas in the mind of the medium, or in that of his demon, for we were treated to an experiment in spirit-rapping in place of table-antics. I would like to have seen that table dance! Professor Faraday's delicate apparatus would have been thrown away upon it. The conceptions of involuntary impulse entertained by our forest medium would have fully satisfied the hypothesis of the professor.

The answers to all questions were given by the visible rappings of his own fingers, but he solemnly averred that a spiritual will directed the movements unconsciously to himself. His evident sincerity led us to infer that he had devoted much thought and yielded too much faith to such unprofitable communings and to fear, lest, as in some other cases, instead of being a revealer of truth to others, the heavenly-imparted light within him should become darkness.

FISHING.

An afternoon's fishing in Teal Lake was a part of the programme for the day. A huge canoe, large enough to hold a war-party of savages, lay upon the beach, ready to launch. The pine, of which it was formed, the glory of the forest, that must have counted its life, like the antediluvians, by centuries instead of decades, had been felled for the express purpose a few days previously. A portion of the company were left upon a rocky point to fish from the shore, another portion embarked on the gigantic canoe for a longer voyage, and the remainder prudently and fortunately commenced their return march to our quarters at the Forge. The clouds that had lowered upon us all day began to gather in blacker masses, and at length two or three heavy peals of thunder announced that the process of condensation had commenced. The rain descended for several hours with the fury of mountain showers, and we reached the encampment thoroughly drenched. The boat's crew, who remained at their cheerful task of fishing in the storm, harassed by swarms of black flies that actually scarified all the exposed parts of their faces and necks, were rewarded with a few small trout for their pains.

The supper was ended, a council was held, and it was determined, without a dissenting voice, to return to Marquette on the ensuing day. So much rain had fallen, that a further exploration of the iron region presented anything but attractive considerations. And there were no auspicious meteorological signs to give us the promise of more favorable weather if we should remain till the waters should have abated from the face of the earth. We had, besides, seen a pile of iron ore that appeared inexhaustible. We, therefore, abandoned our intended visit to Cleveland Mountain, situated at a distance of three miles beyond Jackson, a still more enormous mass of mineral containing some spurs of the best ore, but for the most part streaked and veined in large proportion with red jasper of great hardness; and our projected fishing in beautiful Lake Angeline, lying somewhere near, of whose large and abundant trout hazy but glowing rumors had reached us. So we did not scale the iron crest of Cleveland, nor look upon the virgin face of Angeline.

THE COPPER MINES.

After our return some of the party took advantage of the arrival of a boat bound up the lake, to visit the copper mines at Eagle river and Ontonagon. One or two only ventured down the dark recesses of the cliff in subterranean uniform, with burning candles for feathers, but the rest contented themselves with general inquiries and examinations, and the collection of specimens of the various kinds of ore. I preferred to remain quietly at Marquette. I have no particular fancy for descending mines, and the great copper lottery, with its monstrous ingot prizes and its many blanks, has no attractions for me. If the representations of the owners of the lands, and the projectors of the magnificent schemes afloat, all accompanied with the usual story of Indian tools having been found upon the spot, are to be believed, we are to be abundantly supplied with that useful mineral, when the requisite capital shall have been invested. Those who remained behind the copper party found plenty to interest them in the neighborhood of Marquette.

CHIPPEWA INDIANS.

A part of my employment each day was, to observe the Indians, a large encampment of whom occupied the lake shore near the village, of the same tribe as those at Saut Ste. Marie, and acknowledging the same chief. Inferior chiefs residing at Marquette, are Mongoos, and Marshgepp, or Rising Sun. They are Chippewas, but number among them a good many half-breeds, some of whom speak French. An occasional crucifix in the huts shows the faith which they profess. They subsist chiefly by fishing, hunting and trapping, but live in a miserable way, not knowing how to make a proper use of the good things they get. The whole culinary apparatus of a family consist in a single pot. Everything is boiled in that pot, whitefish, trout, venison, salt pork, duck, pigeon, or whatever it may be, so that, though they live on the choicest fish and game, it is pretty poor and monotonous fare after all. Bread is made by some of the most civilized; others bake in the ashes thin cakes of unleavened dough, while the full savage dispenses with the luxury of bread altogether.

They distribute with generosity the overplus of game taken, or of fish caught among the surrounding huts, after disposing of all that there is an immediate demand for; so that a successful return from watching at a deer lick, from hauling the gill-nets with a good catch of delicious whitefish, or from drifting those deep murderous lines, armed with a hundred baited hooks, on which the lake trout hook themselves, is an occasion of great interest in the community, because it promises a feast after a long famine, perhaps.

The chief lions at the Indian encampment were three young beavers, about the size of a muskrat. They were so tame that the Indians took them a swimming with them and the amphibious pets made no attempt to escape. They were kept in a box strewed with birch twigs and leaves, and suffered the children to play with them like kittens.

They seem to take particular satisfaction in turning and manoeuvering that paddle which nature has given them for a tail, paying the same attention to the instrument, and exhibiting the same consciousness of its peculiarities as an elephant does with respect to his proboscis, delighting to keep it in motion, and twist it into various attitudes, in order to show off its capabilities. But it was not easy to get a sight at the show. Mongoos was in the hut on one occasion when visitors called, sitting erect as a statue, and his more compliant squaw could get no nod, grunt or other sign of acquiescence from the stern chieftain. At other times, a bright quarter of a dollar flamed intelligence into the Indian mind and awakened the idea that the visitor wanted to see something for his money. But if a friend was along who could speak Chippewa, the box was brought forward without a moment's hesitation.

I found the Indians reserved, but disposed to meet graciously any civility extended to them. They respond with dignity to your salutation, and are exceedingly sensible of kindnesses bestowed. Little presents made to them win their hearts, and they seek the earliest opportunity to make presents in return. They are difficult to deal with by strangers as to services, use of boats, and the like, showing slackness and averseness, and demanding invariably unreasonable compensation, but the gift of a new dime to each child in the wigwam, not forgetting the pappoose that lies swinging in the little wind-swayed hammock, stretched like a spider's web across the corner of the hut, (for who ever saw an Indian wigwam that did not swarm like an old bee-hive, all the facts as to the rapid disappearance of the red race to the contrary notwithstanding) will make the whole family your fast friends.

By a mere occasional salutation and the interchange of scarcely half a dozen words, I gained the confidence of a half-breed so completely that he stepped up to me one day and asked me if I would write a letter for him. I complied cheerfully, leading him to my apartment, and wrote from his dictation, and as nearly as possible in his own words. I will not violate confidence so far as to give the epistle verbatim. It will be sufficient to say, that it was addressed severally to a mother, sister and brother, residing at the Saut, whom he had left a year previously. The main object of the letter was to give an account of his success in his new home, explain the reason why he had not joined them at the death of his dear father, which had occurred in the interval, and to promise a speedy visit. He told how he had unfortunately lost in a storm five new gill-nets; of the barrels of whitefish he had caught in the fall, and his disposal of a part of them for flour, at an even barter; and of his luck at trapping during the winter, at which he would have done well, but an Indian down here (one of the chiefs, doubtless), would not let him trap in the woods any longer; specified the seven deer he had killed since spring, and the seven cents a pound at which he had sold the meat, expressing the wish that his brother was with him to help him eat the venison. In the portion addressed to his sister, he told her how excellent a help-meet his young wife Rosalie was to him. He warned his brother against the use of liquor, and at the same time confessed to his mother that he took two or three glasses of brandy whenever the steamboat came in, but not enough "to put him out of the way." Considering that the steamboat had been in shortly before I enlisted as his amanuensis, my friend's letter did him credit, but was particularly interesting, as exhibiting a tenderness of affection in the family relations that I did not before appreciate in the impassive savage. One of the most touching things in the letter, was his earnest request to his brother and sister to take care of their dear mother.

TROUTING.

Trouting was one of our amusements during our stay. Two miles east of the village is the mouth of the Carp river (rivulet) and three miles in the other direction that of Dead river, (Riviere de Mort, so named by the early French discoverers from some Indian slaughter). They are both choice trout streams. The waters were unusually high at the period of our visit, and therefore, at an unfavorable stage for the best sport, but a mess could be obtained at any time without difficulty. Brook trout also venture out into the lake, feeding on the minnows about the rocks along shore, and acquire a more silvery appearance than they have in the leaf-dyed waters of Carp or Dead river. Our sportsmen killed (I believe no sportsman ever catches a trout) a good many ranging from one to two pounds, and one weighing, honestly, on the scales, three and a half pounds.

There is a penalty to be paid for this sport, which must be felt in order to be appreciated. A grievous swarm of flies was one of the plagues of Egypt, and a more serious pest never haunted lake or forest, the home of the deer, the moose, or the Indian, than the black flies which assail the fisherman upon the banks of the Dead river. No unguents will mollify their blood-thirsty rage. Delicate-skinned sportsmen from the city resort in vain to helmets of buckskin, because the entomological enemy creeps in behind these defenses. It is asserted that the time during which the plague of the flies continues is six weeks; but if the flies disappear, the mosquitoes do not. The latter enlist for the whole war, and leave a few hardy sentinels under the shelter of the thickets, even during the long reign of winter.

A singularity of the soil will be discovered by the fisherman soon after his arrival in this quarter. It produces no angle-worms—at least, although the contrary theory was maintained, I could learn of no authentic instance where one had been dug up. Those who have previous acquaintance with the fact bring a supply with them. The trout has a special fancy for this fare. It must be a new delicacy to him, and when mimic flies, thrown with all the skill of practiced art, will skim in vain, when raw venison presents no temptation, and even a floating morsel of his kindred fails to provoke his voracity, an angle worm generally attracts his attention. It is proposed to plant (colonize should be the phrase) some of them for the benefit of future anglers.

The rat, in like manner, is not reckoned among the aborigines of the country, although it is said that they are following in swarms the march of civilization, and helping to populate the mining districts.

GEOLOGICAL PECULIARITIES.

These are among the lesser phenomena which characterize this extraordinary region. One of the most marked peculiarities in the physical structure of the country we noticed at Marquette. The rocks, even the hardest trap, are full of seams, bearing witness to the violence of Plutonic agencies. Beautiful specimens of marble are found here, white mingled with pink and light purple, but it will probably be of small value from this cause. The iron ore has been seamed by the same forces. This shattering of the rocks is observed throughout the whole Lake Superior country, and has occasioned a disappointment of the hopes of the Saut Canal Company in obtaining stone for their locks within a convenient distance. With respect to the copper, the metal was no doubt, injected into the veins where it is found after the upheaval of the rocky strata.

THE CLIMATE AND CONSUMPTION.

A climate of great salubrity is one of the blessings allotted to this region, and will be found an important circumstance in contributing to its development and prosperity. The soil is too sandy to exhale miasmatic vapors, and the odors of pine and hemlock scent the air. The atmosphere is charged with health-giving influences. One can inhale a much longer breath than in our atmosphere, without experiencing any painful sensation.

Marquette has become a great resort for consumptive invalids, and we were informed that every house in the place, affording accommodations for boarders, was occupied by ladies and gentlemen from the states "below." A small shanty upon the lake was pointed out to us as the Invalid House. I ventured to call, and found a club of four gentlemen, companions in disease, who had associated together in the erection of the shanty, attended to their own wants, and contributed according to their ability in supplying the table with fish and game.

It is said that many cures of consumption have been effected. A year's residence is recommended by physicians, the steady though severe winter climate being considered quite as favorable as the more agreeable climate of summer. Many of the settlers here are persons whose constitutions were broken down on the bottom lands of Ohio, and have taken a fresh lease of life by starting anew as pioneers in the wilderness. There is something peculiar about the region as to liability to take cold. Exposures to rain, or wet feet are not followed by the usual consequences. The winter traveler throws himself upon the snow at night with perfect impunity while the thermometer is below zero, and refreshes his wearied limbs upon the whitest and deepest of beds. It is a common saying that no one takes cold on Lake Superior; and yet it is not a dry meteorological district by any means—rather the reverse. Rain falls easily and copiously.

The purity of the atmosphere is surprising. There were times when we could disceren distinctly from Marquette, the high land of Grand Island, forty miles distant. Beautiful mirages, too, with new headlands and forest-crowned islets, rise from the surface of the lake at times. And as for rainbows, if the one I saw is to be regarded as a specimen, this portion of the earth's atmosphere cannot be matched for its prismatic properties. One end of the arch rested upon the rock at the entrance of the harbor, and the other end upon the lake opposite the mouth of Carp river, some two miles distant—and there it stood for an hour, like a door into the heavens, as Jean Paul finely calls the rainbow, painted with the brightest hues from angelic wings! The sublime poem that was sung at the dedication of Solomon's temple seems applicable to such a portal—

> Lift up your heads, O ye gates; and be ye lift up, ye everlasting doors; and the King of glory shall come in.
>
> Who is this King of glory? The Lord, strong and mighty, the Lord mighty in battle.
>
> Lift up your heads, O ye gates; even lift them up, ye everlasting doors; and the King of glory shall come in.
>
> Who is this King of glory? The Lord of hosts, he is the King of Glory.

THE SOIL, ETC.

The soil throughout this region is light and poor, especially on the boarders of the lake. A few miles back, particularly from Whitefish Point to Presque Isle, it is better and covered occasionally with valuable timber. It is fortunate that the soil is warm, otherwise crops which can be now raised could not be produced at all in their brief hyperborean summer. The season is not long enough to ripen Indian corn. Grass grows luxuriantly, and there are occasional natural meadows yielding heavy burdens of wild hay. Oats thrive well. Wheat can be grown in some localities. But the product for which the region is most famed is the potato. The lower country produces nothing to be compared with it in quality or flavor.

The general practice for preserving potatoes during the winter, is to leave them out in the field and dig them in the spring after the snow has disappeared. Snow falls usually about the middle of November, covering the unfrozen ground to the depth of four feet, and protecting everything beneath it with its warm and fleecy mantle. When winter retires, summer immediately enters, crowned with leaves and flowers, treading upon a grassy carpet, the green blades of which have been springing up through the melting snow. This peculiarity of the climate renders the wintering of stock a much less serious business than would be imagined, pasturage continuing as late in the fall, it is said, and commencing as early in the spring as in the State of New York. There are, therefore, ample inducements for farmers to settle in the country, inasmuch as the mines afford an excellent market for everything that can be raised. All the provisions consumed by the miners are transported at great expense, and the cultivation of the land is requisite in order to furnish them with supplies, and reduce the enormous cost attending the employment of labor in this region at present.

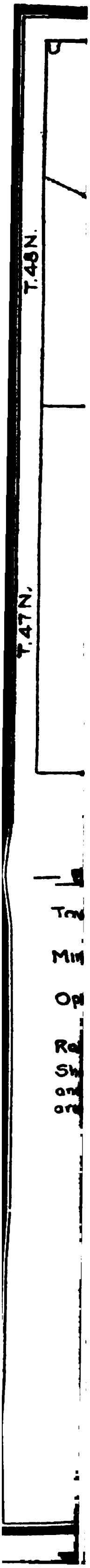
The great drawback to the rapid development of the country has been its inaccessibility. This will be completely remedied during the season of navigation, when the Saut Canal shall be opened. In winter it is completely isolated. The mails, conveyed by a dog-train, go and return from the civilized world once a month during the long period of hybernation, Badenoch, on Green Bay, being the point of communication. But a railroad is already talked of, and there is said to be a practicable route, leading direct to the copper country, and accommodating the intermediate district, that will establish an easy connection with Chicago.

This mineral world is a region by itself, both as to its position and as to its interests. It does not seem to appertain naturally to any of the states near which it lies. The prosperous and beautiful state which lies clasped in the arms of so many lakes, to which the chief part of the mineral country is attached as a mere out-laying appendage, might consent to part with her copper colored daughter. It should be, it seems to me, the mineral state par excellence of our republic, leaving still to California her golden title. An appropriate designation for the new-found star would be "Superior," as being appropriate to its position and suggestive of noble endeavors. The City of the Rapids might at the same time drop its long, unpronounceable baptismal name, and assume also the good and well-sounding name "Superior."

THE PICTURE ROCKS.

We were detained at Marquette some days longer than we wished. At length a boat came down the lake, and brought us back to Saut Sainte Marie. We passed again the Picture Rocks, and saw them under the illumination of the rays of the setting sun. The immense arch, which has so often been described, is the most striking and unchanging feature in the many views which rise and disappear in the changing picture. Towers and bastions, cathedrals, warehouses, bridges, the roofs of a compact city, are crowded upon it. In other positions on the shores of the lake, wherever the same rock is exposed, towns rising from the midst of embowering trees, or reposing in sheltered bays, burst into view.

But a grander sight than a view of the pictorial rocks with their architectural enchantments, was the setting sun, perfect in form and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in the purity of its seraphic brightness—first touching the smooth surface of the waters, then dipping and sinking beneath them, as though the crown of God were falling from heaven into the sea! This is a vision of beauty and majesty for all the inhabitants of earth!

The next morning we arrived at Saut Sainte Marie, where my "Trip to Lake Superior" may be properly regarded as brought to a close.